The NEW NATURAL HISTORY

First Volume

J. ARTHUR THOMSON

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THIS CHIMPANZEE AT THE LONDON ZOOLOGICAL GARDENS, OFTEN SHOWS FINE INSTANCES OF ANIMAL BEHAVIOUR AT A HIGH LEVEL. NOT THE LEAST OF HIS ACHIEVEMENTS IS THAT HE DRESSES HIMSELF AS SHOWN IN THE ILLUSTRATION.

THE NEW NATURAL HISTORY

BY

PROFESSOR
J. ARTHUR THOMSON

VOLUME ONE

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THE NEW NATURAL HISTORY

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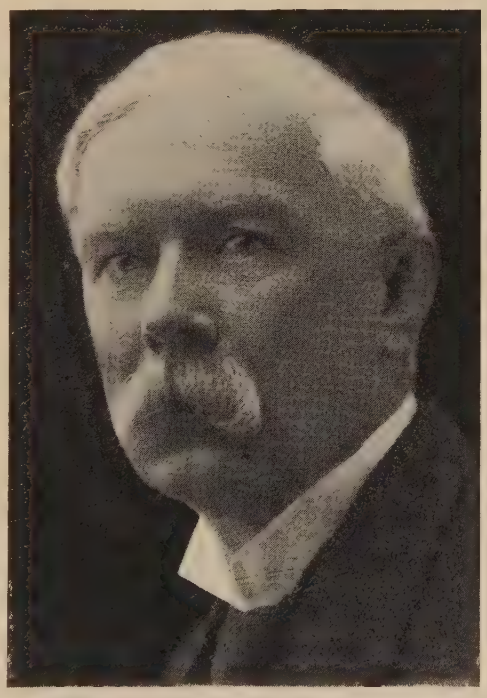
The NEW NATURAL HISTORY

Foreword

THE popular interest in Living Creatures is keener than ever and more widespread. It has been met by an almost embarrassing number of really good Natural History Books, and some warrant may be demanded for adding another to the throng, especially since the object of study should be Animate Nature itself and not any printed page. The reason for this fresh endeavour is hinted at in the ambitious title, "The New Natural History,"—the study of Living Creatures is undergoing subtle change, and our knowledge must be readjusted to meet these changes.



Professor J. ARTHUR THOMSON, M.A., LL.D.,
Regius Professor of Natural History, Aberdeen University.

To Darwin we owe the change that has made the idea of the Web of Life—the inter-relations of organisms—central in modern Natural History. Therefore, the linkages of life find a prominent place in our new presentation. Moreover, while the structure of animals and their classification can never be dispensed with, it is for the unsophisticated student of any age more important to relate the creature to its surroundings and circumstances. For these reasons much space is given in this book to the haunts of life and to the ways in which living creatures are suited to the picturesque variety of habitat from pole to pole. Thirdly, the perennially interesting study of animal behaviour has of recent years become less anecdotal and more scientific, and this is emphasised in our New Natural History by many an attempt to distinguish different kinds of activity on a long inclined plane. This has led us to treat of animals not only as threads in a quivering web of life, but as personalities of a sort, which seek after well-being, which even share in their own further evolution. And in this last word the keynote of our New Natural History is sounded, for, without formal discussion of difficult questions, we have sought to illustrate the biggest fact of all, that Animate Nature is a drama still going on.

University of Aberdeen.

J. ARTHUR THOMSON.

INTRODUCTION

MAN'S RELATIONS WITH OTHER LIVING CREATURES

IT is useful to think of the whole world as three spheres or ellipses, one within the other. Outermost there is the non-living world, the physical universe from dewdrops to stars: what we may call the COSMOSPHERE. Within that there is the realm of organisms, all the plants and all the animals: what we may call the BIOSPHERE. Innermost there is the kingdom of man, with all his societies and achievements: what we may call the SOCIOSPHERE.

Things, Organisms, Man.

The realm of life depends on the domain of things, and the kingdom of man depends on plants and animals. So we may place them one within the other. But their boundaries are not clear-cut; we might almost say that they dovetail into one another, except that the word "dovetail" suggests something fixed. The cosmosphere may intrude upon the biosphere, and the sociosphere too, with terrible destructiveness, as in the case of earthquake or volcanic eruption; but it may also exercise a beneficent influence, as when the climate or the weather changes for the better. Similarly, plants and animals may intrude upon man very destructively, as in the case of microbes and parasites; or they may favour man's interests by providing him with food and raiment.

There is another side to it that we perhaps think of less. The biosphere has had a great influence on the cosmosphere; thus green plants have made most of the oxygen of the air, and forests change the climate.

Photo: John J. Ward, F.E.S.

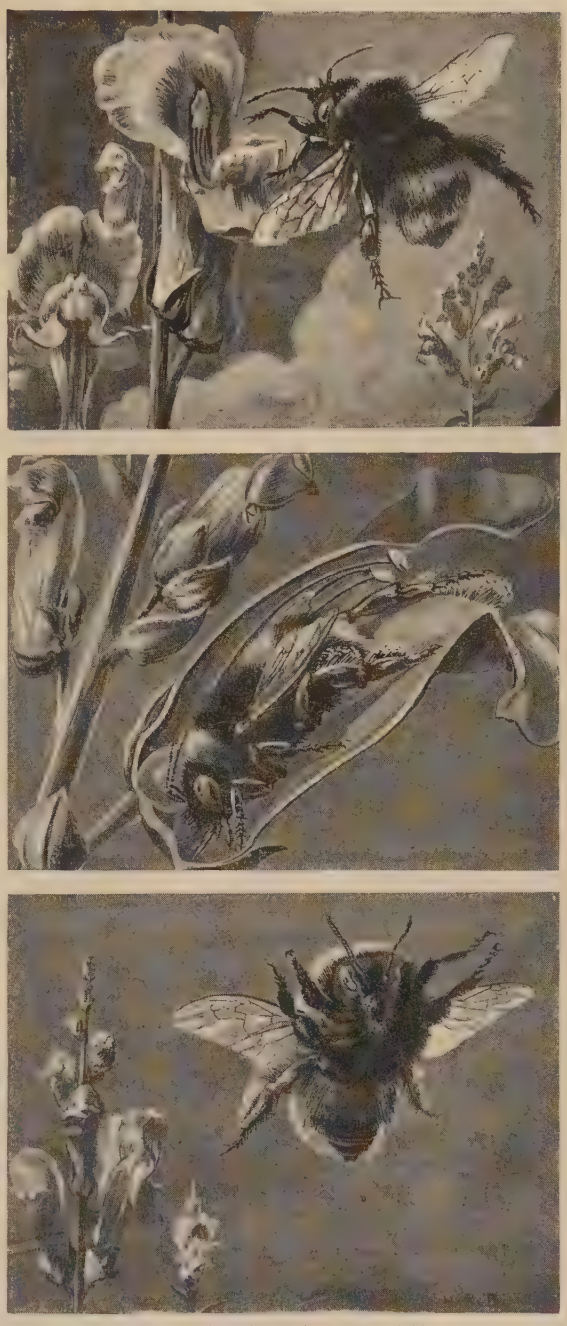
A towering chalk cliff composed entirely of fossilised remains of minute animals with shells of lime. Inset: Shells of Foraminifera greatly magnified. These form a great part of most varieties of chalk rock.

Animals have formed chalk cliffs and limestones, and earthworms have made most of the fertile soil. In cases like the building up of the Great Barrier Reef of Australia, about a thousand miles long, it is not too much to say that the biosphere has taken hold of a big slice of the cosmosphere.

Similarly when man irrigates a large tract of country, making the desert blossom as the rose, he is taking part of both cosmosphere and biosphere into his kingdom. When he turns the Wild Wheat into a cultivated wheat a hundred times more valuable, or domesticates a wolf into a dog, he is making part of the biosphere his own. Unluckily, he often conquers not by improving, but by destroying.

Man's Inter-Relations.

The circle of human life intersects the circles of many other creatures, both plants and animals. There are hundreds of linkages, and they are always changing; we can only give a few illustrations. But let us begin by mapping out the most important. (1) There are the animals and plants that are captured or collected for food. We think of fishes and fruits. (2) There are those that are valued not directly for food, but for the sake of other products, which are sometimes edible, sometimes not. We think of mother-of-pearl, cod liver oil, and the fragrance of flowers. (3) There are those that have been domesticated or cultivated because of their direct or indirect usefulness. We think of sheep and dog, pigeons and bees, wheat and rice. (4) Then come the creatures that help man unwittingly, the earthworms that make the soil, the wild bees that pollinate the flowers, and the bog-mosses that serve as a sponge for the rain. (5) Next are man's enemies, the beasts of prey and the venomous snakes, the poison-ivy and the deadly bacteria. (6) But there are others that injure man indirectly by attacking useful animals and useful plants; and here must be included the field-voles, the injurious insects, the rusts, the moulds, and hundreds more. (7) Somewhat different are those that injure man not directly, nor through his stock and crops, but by getting at his stores or permanent products. We think of rats and mice, white ants and furniture beetles, and the "dry rot" fungus in the floor of the house. (8) Last are those animals that keep a check on the three contingents (5, 6, 7) previously mentioned. They are man's *indirect friends*, like the birds of prey that keep down the voles, or the lady-bird beetles that levy toll on the green-flies. This classification is taken from a British Museum Report on Economic Zoology by Sir Ray Lankester.



ONE OF NATURE'S LINKAGES.

A bumble bee entering the cup of a snap-dragon blossom, in search of honey. It leaves laden with pollen, entangled in the hairs of its body, and with this fertilises the next snap-dragon flower visited.

I

THE WEB OF LIFE

A LIVING science is always becoming new; and so it is with Natural History. There are fresh facts every week and new ideas every year. Sometimes a new world is discovered,

Photo: W. S. Berridge, F.Z.S.
THE MISSEL THRUSH

like the great abysses of the ocean. Sometimes a new instrument, like the microscope, changes everything. Sometimes a new fact, such as the importance of the ductless glands, like the thyroid, gives a whole science a new aspect. Sometimes two sciences, like Physiology and Chemistry, join hands, and there is great progress.

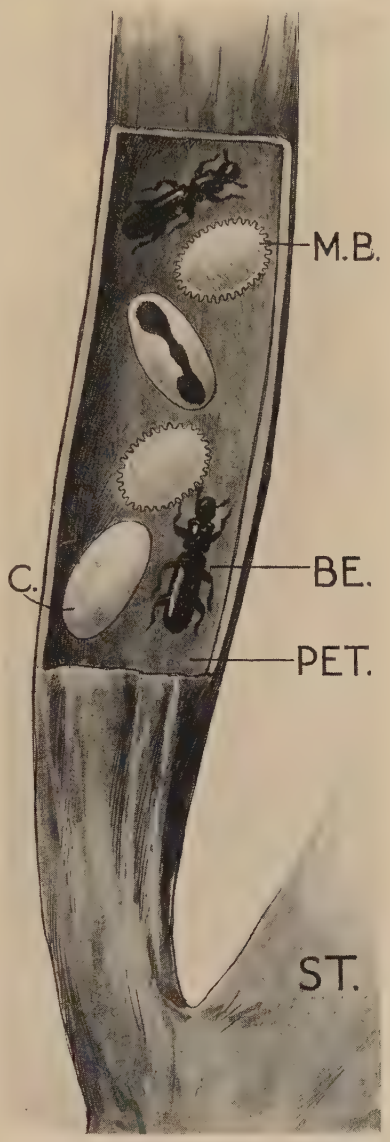
Just as a growing animal is always taking new material into itself and building itself up afresh, so it is with a science. It is not that the old is destroyed; it is rather that the building materials are used over again to make a new edifice of different architecture. Let us illustrate in this introduction some of the new features in the Natural History of to-day. This will give some idea of the way in which this book will deal with the facts of Natural History. We shall begin with the outstanding facts in the kingdom of living creatures, how they are linked together in a web of life, how they have come to be as they are, how they are bundles of fitnesses, how they fill the earth and the waters under the earth, and how they abound in the quality of beauty. We shall then give prominence to their behaviour and habits, their movements and migrations, their quest for food and their endeavours after well-being. Then we shall illustrate their life throughout the year, keeping mainly to animals except when it is necessary

Photo: A. W. Dennis.
and THE MISTLETOE—A LINKAGE BETWEEN BIRD AND PLANT.
The missel thrush, after feeding upon the sticky berries of the mistletoe, wipes its beak upon a branch of a second tree and, leaving the seed in a crevice of the bark, ensures the growth of a new plant.

to show their linkage to plants. Next will come a study of life-histories in their marvellous variety. A large section will be given to a study of animals in their characteristic haunts, from pole to pole. After dealing with the internal life of animals, we shall illustrate their relations to man. A general survey of the Animal Kingdom will bring us finally to evolution—the great process in which the present is the child of the past and the parent of the future.

The Idea of the Web of Life.

One of the ideas that has worked like leaven in Natural History is Darwin's idea of the web of life. The great naturalist meant by this that the circle of every creature's life intersects other circles. Nothing lives or dies to itself. The threads of different lives are woven together and sometimes knotted. As we shall see later on, the bees and the flowers are like hand and glove; the missel thrush plants the mistletoe on the apple tree and the ants sow the seeds of the broom; the minnow nurses the freshwater mussel, and, by devouring larval mosquitoes in the water, checks the spread of malaria. The robber gull or skua chivvies the herring gull and makes it surrender the booty it has caught; the herring gull swallows the fish which again depends on crustaceans; these in turn are dependent on microscopic animals and plants in the open sea. All over the world we find these chains binding different kinds of creatures together, one depending on the other for food. To build up a pound of cod's flesh means that the cod must eat ten pounds of whelks; to make a pound of whelk means that these molluscs must eat ten pounds of sea-worms; and to make a pound of worms means that the worms must devour ten pounds of microscopic minutiæ, the animalcules and particles that form the stock of the sea-soup. Therefore when a hungry man eats a pound of cod, he is eating the transformed result of a thousand pounds of organic sea-dust. When we come to discuss the diverse diets of animals, we shall find many other examples of the way in which the world goes round.



A TRIPLE ALLIANCE IN THE WEB OF LIFE.

The diagram illustrates the curious alliance between a tree (Tachygalia), a beetle (BE.) and mealy bugs (M.B.). The insects live in partnership in the hollow leaf-stalk or petiole, (PET), which is cut open here to show the insects and two beetle cocoons (C.). Tree stem (ST.).

But it will be enough at present to take one good instance of the interlinking of lives. We shall call it *the triple alliance*.

The Story of a Triple Alliance.

In British Guiana there is a tree called Tachygalia, related to the Laburnum, that occurs in two forms—a low shrub in the shade, and a tall tree in the open. The leaves have swollen, spindle-shaped leaf-stalks, which are at first filled with juicy pith. This soon dries up and turns into a loose fluffy amber-coloured tissue, which contains some very nutritious substance. Into this attractive shelter a queen ant gnaws her way and shuts the door behind her. She lays eggs and rears a brood of workers in the amber-coloured fluff. These workers open the door and go out and in. So ends chapter one of this story.

Soon, however, there are other inmates within the hollow leaf-stalk. These are coccus-insects or "mealy bugs" of a particular kind. Whether they come in or are brought in, is not quite clear. In any case, they ensconce themselves among the nutritive fluffy tissue and find

Photo: John J. Ward, F.E.S.

A FITNESS OF NATURE.

1. The grub of the Palisade Saw Fly adopts a remarkable method of protecting itself from its foes. The eggs are laid on the leaves of the black poplar, and when the larva is hatched, it makes a palisade of saliva around its feeding ground that is impenetrable to ants and other enemies. The illustration above shows the female Saw Fly on the edge of a black poplar leaf.

an abundant supply of sap. So abundant, indeed, that they overflow, and the ants utilise the surplus. From one leaf-stalk shelter another is colonised, and the broods of several queen ants probably agree to live in harmony on the tree. If the explorer knocks at the door, the workers rush out in angry crowds, and they dispute the intrusions of other ants who come there to thieve. So ends the second chapter of this story, and we see that there are three parties—the Tachygalia tree, the ant tenants, and the mealy bugs that are middle-men between the two others.

Not long ago, Professor W. M. Wheeler discovered another tenant of the hollow leaf-stalk.

Photo: John J. Ward, F.E.S.

3. The underside of the leaf, showing three swollen spots where the Saw Fly has left her eggs.

This was a small, slender beetle, dark chestnut-brown in colour, and not very unlike some kinds of ants. Except when hungry or disturbed it is rather sluggish, and the observer never saw it fly. A pair of beetles resolve to set up house in a swollen petiole, either in an intact one or in one that has been deserted. In either case they make an entrance for themselves. If they have chosen a previously occupied house there is a good deal of cleaning necessary, and this is done in a somewhat rough and ready fashion, by packing the refuse into the narrow ends of the spindle-shaped cavity. After things are tidy the female beetle lays a few eggs which develop rapidly. Thereafter the mealy bugs appear on the scene; they fix themselves to the amber-coloured fluff and feed heavily. The beetles—

Photo: John J. Ward, F.E.S

2. The pair of saws (much magnified) with which the Saw Fly cuts holes in the poplar leaf in which to deposit her eggs.

both young and adult—are able to eat the fluff for themselves, but they prefer that the mealy bugs should do this for them; and they use the sugary overflow just as the ants do. The fact is that the mealy bugs are in a very real sense the *cows* of the beetles or of the ants, as the case may be.

As the amber-coloured tissue is eaten down, more grows, so that the supply of food continues to be adequate. The undigested residue, passed from the food canal of beetles and bugs, is disposed of in orderly ridges; and a little is used to build a circular tower round the doorway. Here one of the beetles mounts guard, occasionally projecting his feelers and waving them about—a quaint sight on the surface of a plant!

The inmates of the leaf-stalk may now consist of the parent beetles, a dozen or so youngsters of various ages, and about as many mealy bugs. In some of the milk-eating tribes of Central Africa every child has its special cow, so there is usually a mealy bug for each young beetle. Soon, however, there is a second generation of beetles and the mealy bugs also multiply. The house becomes very full of inmates. There are deaths, it is true, and consequent additions to the accumulations in the narrow ends of the spindle, but overcrowding has to be faced. The beetles begin to flit, singly or in pairs, and new households are started in other leaves of the tree. So ends the third chapter in this story: apart from the ants, there is a triple alliance between tree, beetle, and mealy bug.

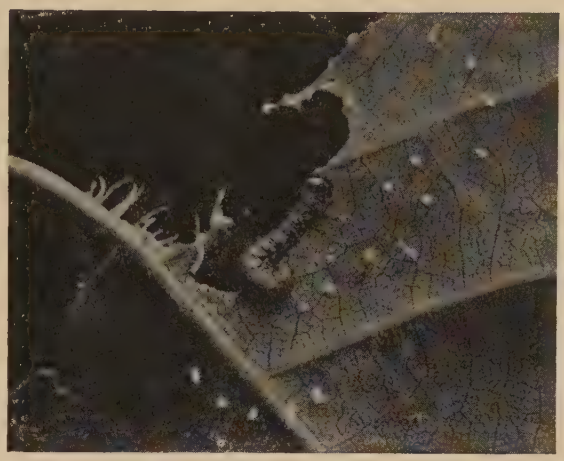


Photo: John J. Ward, F.E.S.

4. The larva feeding near the leaf-stalk and completely barricaded by its self-created stockade. The palisades of saliva, clearly shown, seem to act like poison gas and repel attacking ants.

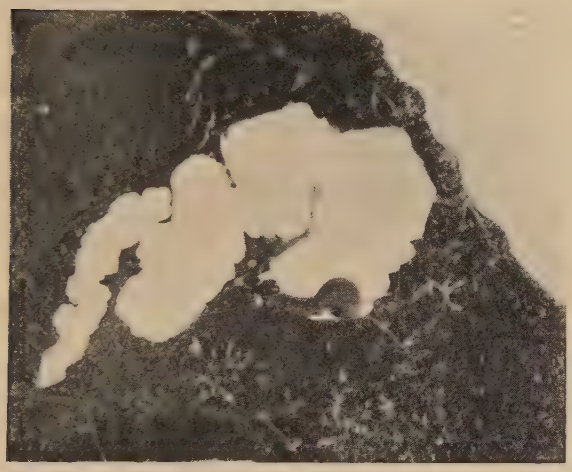


Photo: John J. Ward, F.E.S.

5. The larva is here shown upon a new feeding ground in the middle of a leaf with its protective palisades encircling it.

But before we change the subject we wish to say a little more about the mealy bugs. Only the females were found—small squat pinkish creatures, about a sixth of an inch in length, covered dorsally with white mealy wax, to which they owe their name. The process of milking is very quaint. When a hungry and thirsty beetle comes across a mealy bug, it immediately proceeds to massage it energetically. It beats vigorously with its feelers, using them alternately, somewhat as if it were beating a drum. When the mealy bug allows a clear drop to exude, the beetle licks it up greedily, and asks for more. But it has sometimes to beat for half an hour before it gets drops enough. Moreover, it sometimes tackles a dry coccus-insect and may beat for an hour without getting anything. It is like trying to get milk from a cow that has been already milked. An ant would not persist so long in a fruitless task, but these beetles are not so wideawake as ants. A number of young beetles and adults are sometimes seen crowding round one bug and drumming on it together. But as only one of them can get the clear droplet, there is a good deal of futile hustling and butting.

Where, it may be asked, do the mealy bug's interests come in? The milking does not seem to do them any harm, but we can hardly suppose that it does them any good. We know, however, that they cannot get inside the leaf-stalk unless

Photo: John J. Ward, F.E.S.

6. But though safe against the ant, the gas barrage fails to protect the grub against another enemy, the Ichneumon Fly, which lays eggs in its body.

a door has been made, either by ants or by beetles. An interesting detail is that when leaves are cut off and become dry, the coccids drop from the nutritive tissue to which they were attached; their bodies become thin and somewhat shrivelled. The young beetles soon begin to suffer in the same way, and the adults share in the general discomfort and restlessness. A famine sets in. The beetles, both young and old, turn on one another and cannibalism runs riot for a brief space till all is over. But this happens only inside the stalks of leaves that have been cut off. It does not occur in a state of nature, for the beetles flit if things go wrong.

In spite of the triple alliance it cannot be said that the life of the little beetles is an easy one. They occur only on the younger or shade forms of the Tachygalia, for there are too many ants on the larger tree-like forms, and the beetles have no chance against them. But even on the short shade forms, the beetles have their troubles. There is a little thief-ant, Solenopsis by name, that works at night and burgles the beetles' homes. It finds the door unguarded or it bluffs the porter, and when it gets inside it devours the beetles, both old and young. What it does to the mealy bugs is uncertain. They are compared by Professor Wheeler to the cattle in a disturbed country; in most cases they change masters; occasionally they are devoured. But apart from the dangers involved in the struggles between the beetles and the ants, the mealy bugs have enemies of their own. They are devoured by the grubs of one of the lady-bird beetles; there are midge maggots that envelop them in a white web and devour them at leisure; and there is actually a parasite of the ant-bee-wasp-ichneumon fly order (Hymenoptera) that develops inside the bug-body. We might call this the fourth chapter in our story, which is a vivid instance of wheels within wheels. For we see that many other interests intertwine with those of the triple alliance. *This is the web of life.*

One would like to know how the alliance began, but that is a very difficult question. Did the ants begin to take care of the mealy bugs, just as some of them take care of green flies, and did the beetles learn from the ants? Or did the beetle larvæ, which are restless and inquisitive compared with their parents, begin the habit of massaging the mealy bugs? At present we cannot tell, but this does not affect the facts of the story, which is a fine instance of the inter-linking of lives. It is not a curiosity of Natural History, but a good example of the web of life.

II
ANIMAL BEHAVIOUR

ANOTHER note in the Natural History of to-day is the more exact study of animal behaviour. No doubt, naturalists have been studying the behaviour or "ways" of animals since Natural History began, but the tendency was either to read the man into the beast by being too generous, or to go to the opposite extreme of regarding even the higher animals as automatic machines without any gleams of mind. The delightful stories that Uncle Remus told about "Brer Rabbit," who was really a hare, endow the animal with all the human faculties—the extreme of generosity. On the other hand, many naturalists have described animals as if they belonged to a different creation altogether—without intelligence, feeling, or endeavour; just as if they were clock-work animals. This is the extreme of parsimoniousness.

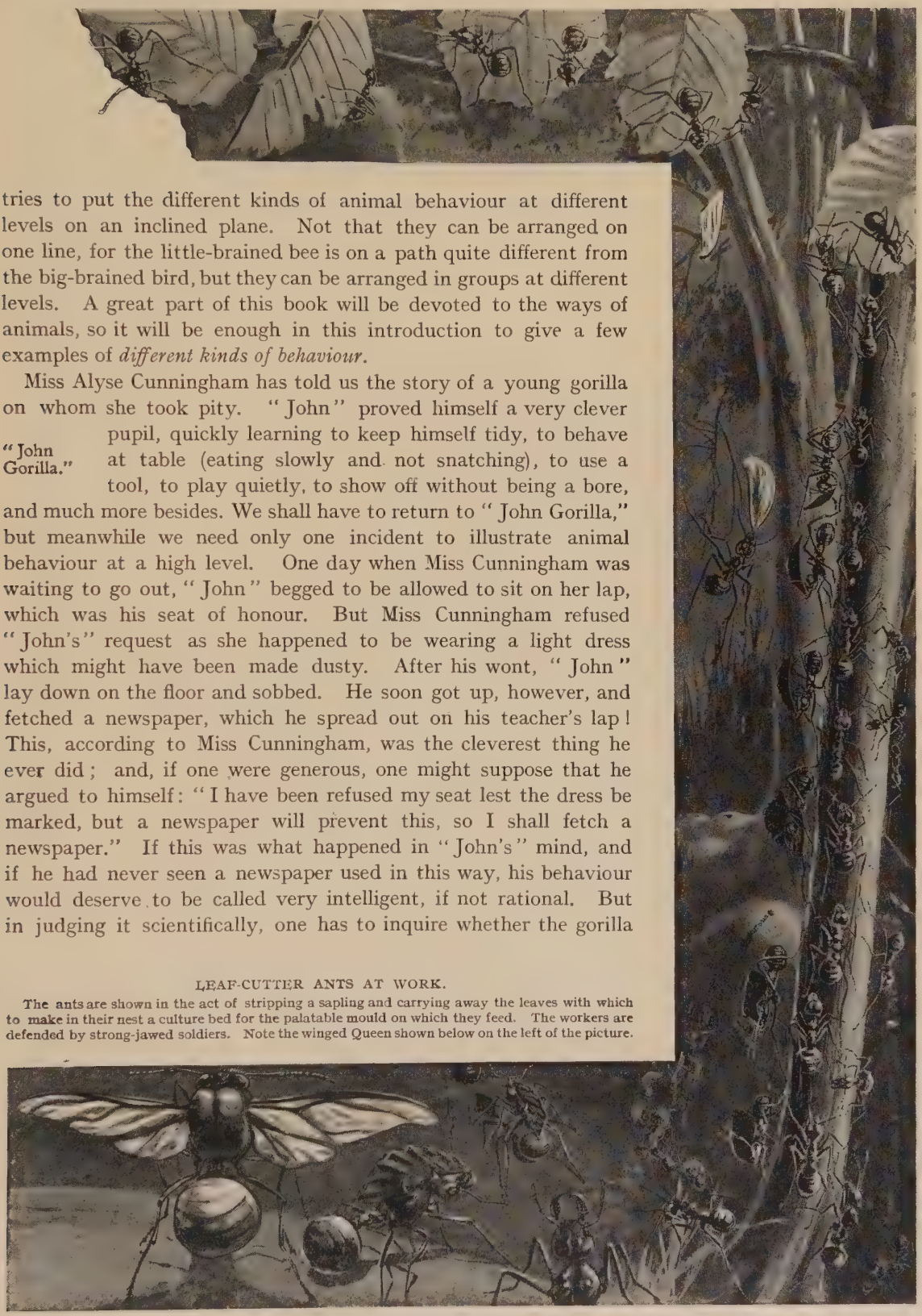
Front view of a winged Queen belonging to a species of leaf-cutter ant, showing the remarkable scissor-like jaws or mandibles. The workers of this species are wingless, but the males are also winged.

Now the Natural History of to-day

tries to put the different kinds of animal behaviour at different levels on an inclined plane. Not that they can be arranged on one line, for the little-brained bee is on a path quite different from the big-brained bird, but they can be arranged in groups at different levels. A great part of this book will be devoted to the ways of animals, so it will be enough in this introduction to give a few examples of *different kinds of behaviour.*

"John Gorilla."

Miss Alyse Cunningham has told us the story of a young gorilla on whom she took pity. "John" proved himself a very clever pupil, quickly learning to keep himself tidy, to behave at table (eating slowly and not snatching), to use a tool, to play quietly, to show off without being a bore, and much more besides. We shall have to return to "John Gorilla," but meanwhile we need only one incident to illustrate animal behaviour at a high level. One day when Miss Cunningham was waiting to go out, "John" begged to be allowed to sit on her lap, which was his seat of honour. But Miss Cunningham refused "John's" request as she happened to be wearing a light dress which might have been made dusty. After his wont, "John" lay down on the floor and sobbed. He soon got up, however, and fetched a newspaper, which he spread out on his teacher's lap! This, according to Miss Cunningham, was the cleverest thing he ever did; and, if one were generous, one might suppose that he argued to himself: "I have been refused my seat lest the dress be marked, but a newspaper will prevent this, so I shall fetch a newspaper." If this was what happened in "John's" mind, and if he had never seen a newspaper used in this way, his behaviour would deserve to be called very intelligent, if not rational. But in judging it scientifically, one has to inquire whether the gorilla



LEAF-CUTTER ANTS AT WORK.

The ants are shown in the act of stripping a sapling and carrying away the leaves with which to make in their nest a culture bed for the palatable mould on which they feed. The workers are defended by strong-jawed soldiers. Note the winged Queen shown below on the left of the picture.

had ever seen Miss Cunningham using a newspaper to cover the bottom of a drawer or a shelf in the wardrobe; one has also to ask whether Miss Cunningham was accustomed to put on an apron when she used a brush to tidy "John"; in short, one needs to know more than the story tells. In any case, the gorilla's behaviour was intelligent, but what degree of intelligence it illustrated requires further inquiry. Our point is that Natural History has become more critical; it is not content to accept every record on its face value.

Let us now take a piece of behaviour which seems to be at a much lower level, though it is in itself even more remarkable. However it may have been worked out in the course of history, it is now part of the hereditary routine and does not require to be learned. In a word, it is instinctive. In his fascinating book, "The Edge of the Jungle," Mr. William Beebe has given an account of the behaviour of the leaf-cutting ants in British Guiana. They live in an underground city and their main industry is to cut off segments of leaves from certain trees. Often there are well-defined pathways in the forest, leading from the nest to the trees, and on these pathways there is a two-fold movement. On the one hand, there is the crowd of homeward-bound ants, each with its fraction of leaf thrown over its shoulder. On the other hand, there is the crowd of empty-handed ants hurrying from the nest to the trees. The observer gets two impressions: he cannot but admire the adroit way in which the pieces of leaf are cut off; on the other hand, he must be astounded to notice that if a homeward-bound ant loses its piece of leaf it is apt to go straight on as if it still had its burden. It might easily retrieve its leaf, but it is, so to speak, wound up to go home and start afresh. This is very characteristic of instinctive behaviour.

Leaf-cutter Ants.

Photo: F. W. Bond.

JOHN GORILLA.
The clever pupil of Miss Alyse Cunningham.

Mr. Beebe put on army boots, thickly smeared with vaseline, so as to baulk the attacks of the soldiers among the leaf-cutters, and with a pick-axe he broke into the underground city. There he disclosed a remarkable sight; for he saw hordes of worker-ants chewing at the leaves which had been brought in, and making them into a green paste, which is the culture-medium for a particular kind of fungus not known elsewhere. This fungus is not allowed to fructify, and it is weeded from other moulds. It forms the sole food of the ants as long as they are below the ground. The ants are in a literal way the gardeners of the fungus.

But there are as usual wheels within wheels, for when a queen-ant leaves the community and rises high in the air on her nuptial flight, she takes with her a minute pill of the precious fungus, carrying it in a depression beneath her mouth. Eventually, she comes to earth again, settles down to maternity, and has a family of workers. When her children are strong enough and numerous enough they bring in segments of leaves and begin to make the green paste. Then the queen-mother takes the fungus-pill from beneath her mouth, where it has been safely kept all this time, and starts a new culture! The story is almost too good to be true, but it is thoroughly well vouched for. Animate Nature is seen to be more and more subtle as we come to know it more intimately.

We shall have much to say in regard to the ways of ants and of animal behaviour in general;

but meanwhile it is enough to make a contrast between intelligent and instinctive behaviour, between the ways of big-brained animals, like the gorilla, and little-brained animals like ants. Looked at from the outside, the behaviour of the leaf-cutters is apparently cleverer than John Gorilla's, but we have convincing evidence that the ape understood what it was doing in a way which is impossible for an ant. The predominantly intelligent animal learns new devices ; the predominantly instinctive animal obeys inborn promptings. The main lines of its behaviour are laid down for it in its constitution ; the intelligent animal blazes new tracks.

III
THE WAYS OF MAMMALS

THE WAYS OF MONKEYS

BEFORE we go on to consider how, in the study of animals, we must look upon everything in the light of history and trace the hand of the past, we shall complete here what we have to say of apes and monkeys. The order of apes and monkeys (Primates) includes several different grades, but the highest monkeys have wits excelling those

Photo : F. W. Bond.

A STUDY IN EXPRESSION.
Two young chimpanzees, Johnny and M'Inghi.

Photos: F. W. Bond.

A CLEVER CHIMPANZEE.

This chimpanzee recently acquired by the London Zoological Society, has aroused much interest by his extraordinary intelligence. He dresses himself, as shown in the coloured plate; he inserts a key in a padlock and unlocks it; smokes a cigarette with relish, and rides a toy tricycle. Here he is seen at table.

of all other living creatures save man. They may be divided into (1) the New World Monkeys, like the Spider Monkeys and Howling Monkeys, (2) the Old World Monkeys, like the Macaques and Baboons; and (3) the Anthropoid Apes, which are also confined to the Old World, and include Gibbon, Siamang, Chimpanzee, Gorilla and Orang.

§ 1. The Senses of Monkeys

It is always well to begin with the senses, for they are the gateways of knowledge and the triggers by which activities are set agoing. Monkeys are very well equipped as regards senses. While the eyes of a dog or a horse look out sideways, the monkey's eyes are directed forwards, as in ourselves. This is a matter of great importance, for it means that a large part of what is seen at any moment is seen by both eyes. This implies what is called *stereoscopic* vision, giving length, breadth and thickness to the picture. Monkeys can distinguish different shapes, even printed letters, and different colours. Bred to a forest life, where alertness is a life-or-death quality, they are quick to detect any sudden movement, or any new feature in their surroundings. The sense of hearing is acute, but the sense of smell is not nearly so keen as in a dog.

But one of the greatest differences between monkeys and ordinary mammals is *the free hand*. It is still used in walking about, but it is not indispensable for that purpose, as it is in a dog. It has become a climbing, grasping, lifting, handling organ, with an acute sense of touch and with a power of feeling around things. No doubt we see something approaching this in some other mammals, such as the squirrel, or the elephant, but monkeys stand by themselves in their power of manipulation and in the linking together of hand and eye. Monkeys use their hand like a tool, and everyone knows how they enjoy taking a thing to pieces, or screwing the handle off a brush and screwing it on again.

§ 2. Restless Experimenting

To understand monkeys, we must recognise that they are endowed with a fine brain. It is at a very high level, and we cannot look into the eyes of a vigorous monkey without seeing, as it were, that suggestions are crowding through its mind. The monkey is restless, and it is restless because it is so clever. Watch a cat or a dog, Professor Thorndike says; it does comparatively few things, and is content for long periods to do nothing. "Watch a monkey and you cannot enumerate the things he does. Everything appeals to him. He likes to be active for the sake of activity."

Photo: F. W. Bond.

JOHN DANIEL, II.

Unlike the popular conception of the gorilla, this creature is full of fun and tricks Here he is seen playing football with a cap, with a basket for a goal.

We see this in the fact that monkeys cannot be satisfied as long as there is anything to be found out. Rudyard Kipling tells us that the mongoose, Riki-Tiki-Tavi, made it his business in life to find out about things, but that is even more true of monkeys. It does not seem too much to say that they are curious about the world.

One of Professor Thorndike's monkeys happened to hit a projecting wire so that it

Photo: F. W. Bond.

A GARDEN SEAT IN THE SUN.

Chimpanzees are sociable creatures and like to spend their leisure in company, rapidly degenerating when kept in solitary confinement.

vibrated. This interested him very much and he went on repeating the trick hundreds of times in the next few days. He got nothing out of it, of course, but it pleased him to make the wire hum.

Monkeys are often astonishingly quick in their movements, and when they get an idea into their head they follow it up with instantaneous action. The thing is often done before we detect what the monkey is going to do! In learning to link two things together, *e.g.*, a sound and an action, they are the quickest of all animals. Sally, a famous chimpanzee at the London Zoo, was taught to give her teacher the number of straws he asked for, and she soon learned up to five. When she heard the sound "five" or "four" or "three," she gathered the right number of straws, and earned her reward. Attempts to teach her above five were not very successful, perhaps because her patience was very limited. When dealing with numbers above five she very often doubled over a straw so that the two ends presented between her fingers and thumb looked like two straws. The doubling of the straw was probably an intelligent device for saving time, and she often resorted to it, though it was never rewarded by her teacher.

The Story of Sally.

Professor Holmes kept an Indian Bonnet Monkey, called Lizzie, second cousin to the Macaque that lives on Gibraltar, and it was very interesting in what it could and could not do. The front of her cage was made of vertical bars which allowed Lizzie to stretch out with her arm. On one occasion an apple was placed out of reach on a board which had a handle that could be grasped. Lizzie immediately stretched out for the handle, pulled the board in, and got her apple. She had no hesitation, but perhaps it was one of the habits of her race to draw a fruit-laden branch within reach. On another occasion Lizzie was given a corked vaseline bottle with a peanut rattling inside. She at once pulled the cork out with her teeth, obeying the instinct to bite at new objects, but she never learned to turn the bottle upside down and let the nut drop out. This is an interesting example of the shortness of the mental tether. She used to get the nut eventually, and in the course of time she got it more quickly than at first, but she never *understood*. Her progress seemed to be due to dropping out useless

The Case of Lizzie.

Photo: F. W. Bond.

"Johnny," one of the chimpanzees shown on page 11, using a hair-brush.

movements, but this is a low-level kind of learning. If Lizzie had learned intelligently she would have turned the bottle upside down.

Monkeys are far cleverer than cats and dogs in learning how to open "puzzle-boxes," where the barriers have to be overcome in a definite order. This is connected with their greater manipulative skill. They try and try again, and drop out mistakes, thus rising above Lizzie's experiences, we can hardly say experiments, with the vaseline bottle. In one case a monkey opened a "puzzle-box" at once after an interval of eight months, thus showing a good memory. Some monkeys can be taught to find their way out of something like the Hampton Court Maze, a feat which probably means a memory of turnings and twistings, and it is interesting to read of two Macaques that they began to smack their lips audibly when they reached the last lap of their course, beginning to feel, dare one say, "We are right this time, the reward is near."

Photo F. W. Bond.

"Mary," a young orang-outan, doing her daily exercise. Amiable in youth the orang-outan becomes morose as it grows older, but this is probably the result of artificial conditions.

There is a common idea that monkeys are great mimics, and we suppose this is partly true. We once watched two chimpanzees washing out their cupboard and it was interesting to see them "wringing" the wet cloth in the approved washer-woman fashion. It is likely that they did this because they had seen it done. But the results of experiments with monkeys point on the whole to the conclusion that each monkey has to find out a solution for itself. Even with such a simple problem as drawing a piece of food within reach by using a crooked stick, it often seems of no use showing the monkey how it is done. But this is not invariably true, and this reminds us that there are many grades of monkeys, some much more intelligent than others.

What is certain is that monkeys are restless and yet persistent experimenters, that they often solve rather difficult problems in manipulation, and that they can remember solutions. Perhaps the cleverest monkey (or ape rather) as yet studied, was a performing chimpanzee called Peter, who could skate and cycle, thread needles and untie knots, smoke a cigarette and string beads, knock in nails and use a key to open locks.

The Achievements of Peter.

One of Peter's best tricks was riding a bicycle in and out between five bottles set in a figure 8. Of considerable interest is the fact that in using a hammer and a screwdriver he did not confuse nails and screws. On one occasion a peculiar kind of hammer was given him as a test; he carefully felt the two ends of the head and then used the flat one, not the round one. In the performance that Peter gave on the stage there were thirty-six separate

Photo: F. W. Bond.

"Johnny" drinking cod-liver oil, which is used as a safeguard against tuberculosis, the worst foe of monkeys in captivity.

acts which followed one another in orderly sequence, and when he was at his best there was no detectable prompting. The trainer seemed to do nothing but assist with the stage properties. Though the performance was evidently enjoyed by the ape, the strain was probably too severe, for Peter did not stand it long and died when he was about seven years old.

Of another trained chimpanzee called Suzette, Dr. W. T. Hornaday, Director of the New York Zoological Park, tells us in his delightful "Minds and Manners of Wild Animals" (1922), that she was a brilliant "trick" bicycle rider and was entirely at home on roller skates. "She could stand upright on a huge wooden ball, and by expert balancing and foot-work roll it up a steep incline, down a flight of stairs, and land it safely upon the stage, without once losing her balance or her control." It is difficult to estimate the degree of intelligence which such a feat involves, but there can be no doubt that its success depends on rapid and sure practical judgments.

From Prof. Wolfgang Köhler's "The Mentality of Apes." By permission of the publishers, Messrs. Kegan Paul, Trench, Trübner & Co., Ltd.

"SULTAN," a chimpanzee, though quite untrained has sufficient intelligence to fit together the joints of a bamboo rod, thus making a double stick that enables him to reach fruit placed outside the bars of his cage.

Everyone must agree that apes and monkeys, like horses and dogs, cats and elephants, exhibit *intelligent* behaviour. We mean that they do things which cannot be satisfactorily described without supposing that the animals can put two and two together. We cannot make sense of what they do without supposing that they say to themselves inside their head, "If this, then that." We must credit them with doing a little thinking, with what is technically called "perceptual inference." That is to say, they have a little experiment game in their minds, the counters in the game being memory images or pictures of things. If they experimented with "general ideas," such as "man" or "reward," as we sometimes do, that would be reason or "conceptual inference," but there is no sure case of an animal rising above the level of intelligence.

Have Apes and Monkeys Reason?

It is very important to get this matter clear, so let us illustrate it in reference to the gorilla, mentioned in the previous chapter.

In 1918, Major Rupert Penny bought a young male gorilla in a store in London, rescuing him from "a daily atmosphere heated to 85 degrees and a nightly condition of solitude and terror." The child-ape was educated by Miss Alyse Cunningham, who kept a record of her pupil's progress. After his childish loneliness at night was removed, "John" began to be happy. He learned to like to be tidy; he fed chiefly on warmed milk and fresh fruit, also warmed; he ate slowly and behaved well at table. If he turned on the water tap he always turned it off again when he had finished drinking. He played by himself and with a child of three. He liked young animals, such as lambs and calves, but was afraid of the full-grown. He enjoyed playing to the gallery, and would unlock the sash and throw the window up so that he might show off to the crowd below. He would clap his hands and beat his breast with his fists after a fashion which Du Chaillu described—only to have his story discredited. John was very cautious himself, and he was curiously nervous about people he was interested in; for instance, if anyone looked out of a high window. He was not always "good," but no bodily punishments were of use. "We found out that the only way to deal with him was to tell him he was very naughty, and push him away from us; when he would roll on the floor and cry, and be very repentant, holding one's ankles, and putting his head on one's feet."

In this connection it is interesting to notice

Photo: F. W. Bond.

A FAMILY GROUP OF SACRED MONKEYS (*Cynocephalus hamadryas*).

Natives of Abyssinia, they are near relatives of baboons and mandrils, but are marked by their shoulder-cape of long greyish hair and the thick, slate-coloured whiskers that stand out prominently most of all in the old males, on the sides of the ruddy face. They are notorious for their organised pillaging expeditions to the cornfields.

Photo: F. W. Bond.

THE BONNET MACAQUE.

One of a family of monkeys inhabiting Eastern Asia. The Bonnet is an Indian species.

Photo: F. W. Bond.

THE RHESUS MACAQUE.

This creature, like the crab-eating Macaque, is perfectly at home in the water, swimming and diving well.

Photo: F. W. Bond.

THE BLACK AND WHITE ABYSSINIAN GUEREZA.

The jet-black coat of this monkey makes vivid contrast with its snowy ruff.

Photo: F. W. Bond.

THE CERCOPITHEQUE OR GUENON MONKEY.

One of a numerous species that are widely distributed over the African continent.

his behaviour when his playmate, a little girl of three, had a tumble. "If she ever cried, and her mother would not go and pick her up, John would always try and nip the mother, or give her a smack with the full weight of his hand, evidently thinking she was the cause of the child's tears." But it is very difficult to be sure what the child-ape was thinking. Perhaps it was something like this: "My little playmate is crying, crying as I do on the floor when I have been pushed away by those I love. What shall I do to her mother, who will not even lift her up again? I shall go and strike her mother even if I have to cry, too." If the ape thought anything like this, then what he did was *intelligent* behaviour—mistaken, of course, just as our own often is, but nevertheless intelligent. If, on the other hand, we could believe that "John Gorilla" said to himself: "This is gross injustice, making my charming playmate cry; I, John Gorilla, must protest," then we should have to credit him with Reason or using general ideas. But this interpretation is far too generous—and the first likewise. The probability is that the child-ape was angry and puzzled, and that he struck the mother, as a child sometimes does, with no more intelligence than when he struck his own breast with his fists.

We have already referred to the way in which the gorilla covered his teacher's light dress with a newspaper; let us quote Miss Cunningham's account of another incident, which, though less striking, is "very human." "A piece of fillet beefsteak had just come from the butcher. Inasmuch as occasionally I gave him a small mouthful of raw beef, a small piece of the coarser part of the steak was cut off, and I gave it to him. He tasted it, then gravely handed it back to me. Then he took my hand and put it on the finer part of the meat. From that I cut off a tiny piece, gave it to him, and he ate it. When my nephew came home he wouldn't believe it, so I tried it again, with the same result, except that then he did not even attempt to eat the coarser meat." The first episode, with its impromptu action, was of course more interesting than the second.

Photo: F. W. Bond.

THE SQUIRREL MONKEY OF BRAZIL (*Chrysothrix*).
This is a gregarious and arboreal species of the tribe, but its long tail is not prehensile. The head is prolonged backwards. It feeds chiefly on insects, small birds and eggs.

Photo: F. W. Bond.

THREE RING-TAILED LEMURS OF MADAGASCAR.
Marvellous climbers, these creatures are nocturnal in their habits, as their large eyes suggest, and make the forest resound with their loud cries. Far below the level of monkeys, as indicated, for instance, by the somewhat fox-like muzzle, they are chiefly fruit eaters.

Behaviour of other Apes.

Professor Köhler, a psychologist, who has had unusual opportunities of studying chimpanzees, tells us how even a feeble one will try with all its strength, as well as with beseeching gestures, to save

another from being punished by the keeper; and how a female rushed to the help of an invalid youngster that had collapsed on the ground. Though not its mother, she was most motherly, and laboured strenuously to lift the prostrate youngster to an erect posture. There are scores of similar examples of good feeling and effective action.

On one occasion Professor Köhler buried a pear in the sand before the cage of a chimpanzee who eyed him watchfully. After an interval —varying in different experiments and rising to an hour — a stick was put into the cage. The ape seized it promptly, thrust it between the bars, and dug up the pear. This must be ranked as intelligent behaviour.

In other experiments with several chimpanzees an interval of sixteen hours was allowed to elapse after the burying of the pear. But when the opportunity was given, the apes went straight to the cache in the sand and dug up the fruit. The necessary control experiments were made, and there seems no doubt that this was a case of intelligent behaviour. There was a memory-image of a desirable object and there was a precise controlling of movements in relation to a recollection of the position of the hidden treasure. But no one who uses the word "reason" to mean something beyond "intelligence," would say that there was in the fruit-finding any hint of reason.

There are a few cases, however, where the behaviour seems to us to rise close to the rational level. Dr. Hornaday tells of a captive orang named Dohong, who seemed to have the joy of discovering or inventing the lever. "As fairly and squarely as Archimedes discovered the principle of the screw," Dr. Hornaday says, but the use of the word "principle" is begging the question. What happened, however, was very remarkable. Dohong found out for himself how to use a lever, and then he proceeded to make other levers, sometimes of larger size. This was very intelligent, for it was getting beyond a particular situation. A lesson learned on one occasion was utilised on other occasions when the particulars were different. With the utmost good nature and cheerfulness, Dohong made use of his levers to wrench off the brackets in his cage and to destroy two large sleeping boxes on the balcony. For a long time he had been vexed because he could not put his head out between the bars of his cage and look round into his next-door neighbour's house—a very natural desire. "Very soon after he discovered the use of the lever, he swung his trapeze bar out to the upper corner of his cage, thrust the end of it out between the first bar and the steel column of the partition, and deftly bent two of the iron bars outward so that he could easily thrust his head outside and have his coveted look." If ever a creature delighted in "bringing things off," it was this orang.

Photo: The New York Zoological Society.

"SUZETTE," a clever chimpanzee, that was not only a trick bicycle rider, but very much at home on roller skates. The opposable big toe is very well depicted in the illustration.

To sum up, we must credit apes and monkeys with a restless, alert brain, with experimental eagerness, with long memories in some cases, with a capacity for apprehending relations so that they could argue from what they had done in one case to what they should do in a somewhat similar case. In short, some of them attain to a high degree of intelligence.

IV
THE BEAUTY OF LIFE

MOST living creatures are beautiful, by which we mean that they please us in a particularly delightful way. For the best definition of the beautiful is the simple line: "A thing of beauty is a joy for ever." Beauty is a quality in things that gives us a pleasant thrill unlike any other thrill. We cannot have too much of it; it never palls. It is increased in us when we share it with others. It is quite different from a general feeling of well-being, for it always refers to particular things that we see here and now.

Think of some beautiful sights: a troop of Shetland ponies racing in a field, a dozen lambs playing "tig" in the meadow, a kingfisher darting upstream like an arrow made out of a piece of rainbow, a shoal of mackerel in a sunlit sea, a bank of shells splashed by the tide, a spider's web covered with hoar frost, the butterflies flitting from flower to flower, a living sun-star gleaming like a tiara of rubies, a fleet of jellyfishes throbbing in the waves, a coral-reef like a flower-bed, a crowd of sea-anemones nestling like chrysanthemums in the niches of the rocks. Or, among plants, remember the grace of the birch trees, the glory of a yellow poplar in the spring, when it rises like a golden fountain in the air, the white water-lilies floating in the pond, the gorgeous Alpine meadow, the blue-bells ringing

Beautiful Sights in the World of Life.

Photo: Captain Frank Hurley.

THE GREAT BARRIER REEF OF AUSTRALIA,

at low tide, showing some of the forms of coral growth. The colours of the living corals are gorgeous beyond description, but when the polyps die off and their skeletons or shells are cleaned the prevailing colour is white.

by the roadside, the quaking-grass with its flower-heads quivering like aspen leaves, the withering maples in autumn, the laburnum's "dropping wells of fire," the wood-hyacinths like "the heavens upbreaking through the earth." And what shall we say of the Wood Horsetail, with its whorls of drooping branches, or the delicacy of the feathery moss, or the resplendent colours of the seaweeds thrown up on the beach? It almost takes our breath away to come suddenly upon a Royal Fern (*Osmunda regalis*), growing four feet high, in a curtained corner beside a waterfall in the glen—

> "Plant lovelier in its own recess than Grecian Naiad seen at earliest dawn tending her font, or lady of the mere, sole sitting by the shores of old romance."

There is no doubt that beauty is the rule in Wild Nature, and we venture to say that it is seen in all fully-formed creatures that man has not meddled with, and that live independent lives. The exceptions seem to prove the rule. Cabbages are not very beautiful, but they are artificial results of man's cultivation. Some of the toadstools are not very beautiful, but they are either thievish plants or dependent on rottenness. Many sprouting seeds are rather quaint than beautiful, but they are unfinished. A cankered tree is often ugly, but perhaps most diseased plants are the victims of overcrowding and oversheltering under man's care.

Beauty Almost Universal.

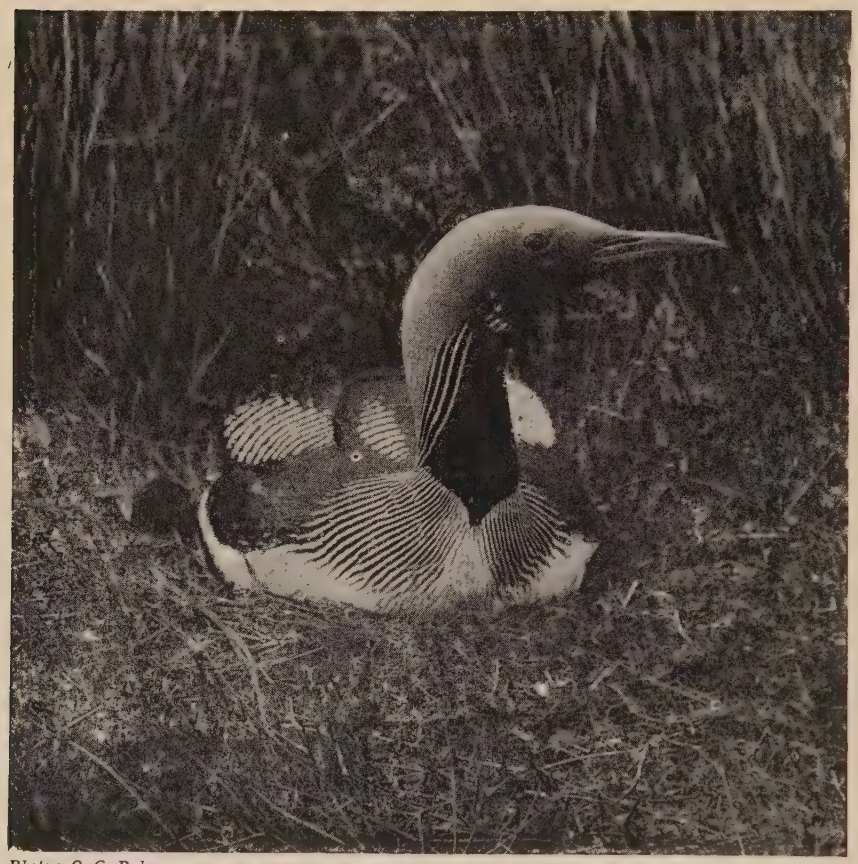


Photo: O. G. Pyke.

THE BLACK-THROATED DIVER (*Colymbus arcticus*).

One of the most exquisitely plumaged of British birds. The black throat has a purplish-greenish sheen, and on each side of the neck there are black and white wavy lines. There are other beautiful lines and dashes on the breast and curious white spots on the back and wings.

Similarly for animals. A prize pig is often ugly; a wild boar is handsome. A young bird inside its shell is not very beautiful, but it is only half-made. A yard-long tapeworm is not very beautiful, and some of the fish-parasites have deformed and unpleasing bodies, but these are not living independent lives. A mangy dog is ugly, but skin-parasites *seldom* run riot in the strenuous conditions of wild life. A diseased or very aged horse or dog has lost the beauty that once was there, but in Wild Nature there is almost no disease or over-ageing. Just as Nature is all for health, so Nature is all for beauty, the reason being that wild plants and animals are harmonies that have stood the test of time, and have had all the discords and incongruities—if they ever had any—sifted out of them. Beauty is the visible outcome of orderly,

Photo : John J. Ward, F.E.S.

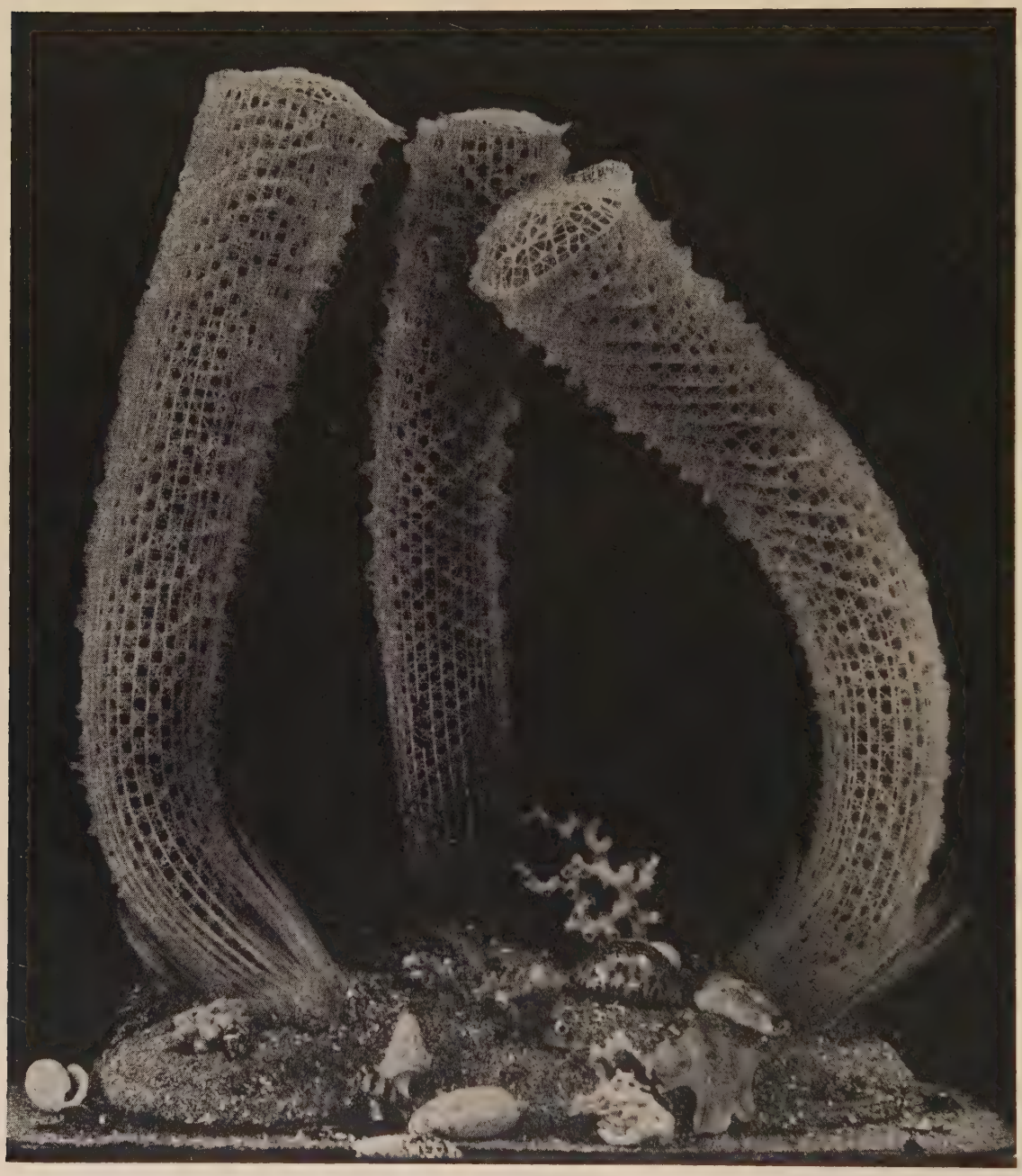
THE COMMON GARDEN SPIDER AS A WEAVER OF BEAUTY.

The delicate tracery of the spider's web is here displayed, showing the spinner in the hub of her concentric system. This is one of the finest examples of instinctive skill.

harmonious, healthy living. "The ugly," as George Meredith said, "is only half way to a thing"; it is like a discord in music. Apart from the exceptions noted, is there any ugliness in Wild Nature?

Everyone enjoys a peacock's tail: that is overflowing gorgeous beauty. It is not so easy to admire the beauty of the snake, partly because man is prejudiced against it, partly because its beauty is subtler. There are fine paintings that we do not appreciate the first time we see them,

Easy Beauty and Difficult Beauty.



VENUS'S FLOWER BASKET (*Euplectella*).

The exquisite flinty skeleton of a deep-sea sponge, this beautiful specimen of nature's handicraft is often fished off the Philippines, but the genus is also represented in the North Atlantic. It is a hollow cylinder, with a large central cavity; but what is shown in the illustration is the skeleton only, all the tissue having been cleaned off. In life it is clothed with living cells. Inhalant pores for the water correspond to the quadrangular meshes of the skeleton.

Photo: G. H. Hewison.

SECTION OF THE COMB OF THE HONEY-BEE.

A fine example of the beauty of symmetry, every cell a perfect hexagon, the whole constructed with the utmost precision. Some cells show bee-grubs.

for some training is needed. Everyone admires a briar-rose bush in flower or a cherry tree; that is overwhelming beauty. But there is great delight to be got out of a tiny Filmy Fern—its branching fronds are very pleasing and the liquid green is exquisite. Not very long ago people were enthusiastic over orchids—and these flowers are often bewitching. But there is great beauty in the homeliest flowers, the bluebells, the violets, and the honeysuckle. People used to be enthusiastic over tropical birds—and some of the male Birds of Paradise are superb beyond description—but there is wisdom in what we now realise, that beauty crowds us at our doors. The chaffinch outdoes the cockatoo.

As Walt Whitman says:—

"The leaf of grass is no less than the journey-work of the stars,
And the ant is equally perfect, and the grain of sand, and the egg of the wren,
The tree-toad is a masterpiece for the highest,
And the running bramble would adorn the parlours of heaven,
The narrowest hinge in my hand puts to scorn all machinery,
And the cow crunching with depressed head surpasses any statue,
And the mouse is miracle enough to stagger sextillions of infidels."

Different Kinds of Beauty.

There are three chief kinds of beauty—of form, of colour, and of movement. Some shapes are much more pleasing to our eyes than others. We like curves better than sharp corners. We do not care for a shape that is "anyhow," like that of some fish parasites. A shape that puzzles us never pleases us. There are lines that flow and shapes that sing. Think of the exquisite form of a convolvulus flower or the curves of a scallop shell. We like ovals, such as we see in the eggs of most birds, spheres like a sea-urchin, stars like a sun-star, "hearts" like a heart-urchin, spirals like a Pearly Nautilus, and so on to the complicated shapes of bird and butterfly.

It is interesting to notice that a certain kind of spiral keeps cropping up in many different

Photos: G. H. Hewison.

THE BEAUTY OF INSECTS' WINGS.

The delicacy of animal architecture is well shown in these two illustrations of common British species.

Above: COMMON DRAGON FLY (*Agrion pulchellum*)
On left: WINGED APHIS OR GREEN FLY.

kinds of living creatures; it seems to be the outcome of orderly rhythmic growth that gains in strength as it continues. We see it in the scales on a fir-cone, in the neat packing of the young leaves within the bud, in the arrangement of the full-grown leaves on many a stem, and often in the arrangement of the parts of the flower. The spiral arrangement of the young leaves inside the bud-scales, which protect them from cold and wetness and drought, allows a large number to be contained in a small space. If the little shoot that forms the core of the leaf-bud were elastic and could be pulled out, as it afterwards grows, we should have the spiral arrangement of leaves that we see on many stems. And here again there is a use, for the spiral arrangement prevents successive leaves from overshadowing one another. We see that there is often a use in beauty.

Following the spiral into the animal kingdom, we find it in the beautiful twisted horns of many antelopes, in the six-foot-long tooth of the male narwhal or unicorn, in the spiral of many snail-shells like the mitre. We find it again in many a spider's web. In most cases, though not in the last, it spells orderly growth.

Then there is beauty of colouring, and here we find an Aladdin's cave. Man sometimes makes combinations of colours that give one pain; they are like discordant noises. But there is nothing of this in Wild Nature—though some of the combinations, for instance in parrots and some butterflies, are extraordinarily daring. The reason is that the colouring-materials (or pigments) are the by-products or waste-products of wholesome living. Their beauty is often enhanced by gradations that depend on a waxing and waning in the intensity of life when the colouring matter was laid down; and sometimes, too, its brilliance is increased by the particular structure of the surface, which again depends on the orderly growth.

Photo: A. W. Dennis.

FRUCTIFICATIONS OF A COMMON ENGLISH LICHEN (*Cladonia fimbriata*).

Better known by the name of "Fairy Cups," these delicate little goblets disclose unsuspected beauties in colour and structure under the magnifying glass. Here they are shown four times natural size.

Here we must notice that there are three kinds of colouring among living things or what these make. First there is colouring due to the presence of coloured material or pigment. The redness of our blood is due to a pigment called hæmoglobin; the greenness of the leaf is due to a pigment called chlorophyll. The bluishness of

Photo: Reginald A. Malby.

AN EXAMPLE OF A BEAUTIFULLY SHAPED CONE, THE FRUIT OF THE MOUNT ATLAS CEDAR.

All cone-bearing trees have beauty of symmetry, but more especially the cedars. The hard, woody cones are the female flowers of the tree.

Photo: Reginald A. Malby.

BEAUTY IS EVERYWHERE FOR THOSE WHO HAVE EYES TO SEE IT.

In the meadow, or on the mountain-side, grow many different grasses which, common as they are, yet have blooms of fairy-like form and delicacy. The Quaking Grass (*Briza maxima*), a beautiful British species, has flower clusters on very delicate stalks.

a living lobster is due to a pigment called animal-red (or zoonerythrin), and everyone knows that it changes to red when the animal is boiled. Or, again, the colour of the leaves of a Copper Beech is due to a mingling of a reddish pigment (anthocyan) with the green chlorophyll.

But colouring may be brilliant without there being any colouring matter. We are familiar with this in the "blue sky," the "blue sea," the "red sunset," and the "rosy dawn"; and the same is true among living creatures. Just as the colours of the rainbow are due to the falling raindrops breaking up the white light into its component colours, so the inside of many a shell, such as that of the Mother-of-Pearl oyster, is brilliantly "iridescent," but without any pigment being present. If we pound a little piece into powder it is just white chalk. The beautiful whiteness of a Narcissus flower is due to the total reflection of the light from little bubbles of sap in the cells. If we squeeze a part of the flower against our finger nail, breaking all the minute mirrors, it is quite transparent. Similarly the whiteness of the hairs of the ermine or the feathers of the ptarmigan in winter is due to the total reflection of the light from minute bubbles of gas in the internal structure. One of the whitest things in the world is foam, and that is due to the total reflection from the surfaces of the bubbles; in most cases of whiteness in plants and animals, we have to do with *living foam*. The silvery whiteness on the under-side of a flat-fish, like a plaice, is due to reflection from little crystalline spangles of a waste-product called guanin.

The third kind of colouring is due to a combination of the two others, and we see it to perfection in the peacock's tail and the wings of butterflies. There is a pigment present, but its colour may be improved or entirely changed by the physical character of the surface. Thus there are often very fine lines or striations which break up the light. Whenever there is this kind

Photo: Reginald A. Malby

THE "COTTON GRASS" (*Eriophoron*), one of the sedges and not a true grass. It is found chiefly on the moorlands, and is at its best in June and July.

Photo: Reginald A. Malby.

THE BROME-GRASS (*Bromus macrostachys*).
A fine example of delicate beauty.

of "iridescence" or metallic glimmer it is due to the physical structure, either alone (as in mother-of-pearl), or in combination with pigment (as in the plumage of the Birds of Paradise). The colour changes as the animal moves, and its brilliance disappears if the surface is badly bruised. We understand, then, that a living creature may have a bright colour, such as blue or green, without there being any blue or green pigment.

We noticed that beauty of form may have a use, as in the spiral arrangement of leaves, and we get many other examples in connection with colour beauty. For it may have the effect, for instance, of making the animal almost invisible, or of making it attractive in the eyes of its desired mate. The colouring may protect the plant against the hardships of winter (as in the reddening of the blaeberry and Alpine Bearberry), or it may serve as an advertisement to welcome insect-visitors, drawing them to the flower. Many colours have uses.

Besides beauty of form and beauty of colouring, there is beauty of movement, which is, of course, practically confined to animals. In many cases all the three kinds of beauty are seen at once, as in birds and butterflies; but even a soberly coloured animal may have fascinating movements, as is well illustrated by the dolphins gambolling in the sea. It is difficult to pick and choose—we recall the ordinary flight of seagulls, and their gliding against the wind, the sailing of the albatross round the ship or of the vultures at great heights, the mysterious and fearsome movements of the snake, the swimming achievements of fishes, the graceful leisureliness of the sea-horses among the weed. We picture the band of cuttlefishes swimming together and keeping time; the butterflies fluttering from flower to flower; the Æsop prawns changing colour as they jerk themselves from one seaweed patch to another; the fleet of jellyfishes in the tide. Sometimes it is the grace, sometimes the dance-like rhythm, sometimes the masterfulness

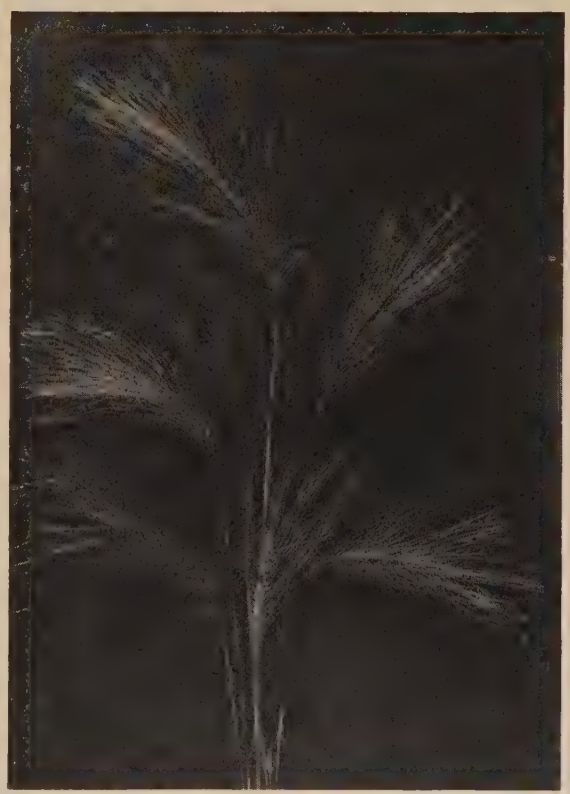


Photo: Reginald A. Malby.

WILD BARLEY (*Hordeum jubatum*).
The beautiful flowers of this grass are marked by the very long awns.

—the movements of animals give us great delight. There is often music in them.

Beauty in Things made by Animals.

We have been thinking mainly of living creatures themselves and the beauty of their own bodies. What a triumph there is in a cherry-tree in full blossom or in a flock of peewits wheeling over our head! But there is often great beauty in what living creatures *make*. We shall not count shells and the like, for though there is no life in them, they are, as it were, chiselled from within. They are directly produced by the living skin. We refer rather to structures like the honeycomb of the hive, the wasps' hanging house, the spider's web, the bower-bird's bower, the nest of the wren. They are works of art in a sense. They are certainly very beautiful.

V

THE STORY OF THE BOWER-BIRD

Many birds make very beautiful nests; that of the chaffinch, for instance, is a masterpiece.

The Story of the Bower-Bird.

But part of the beauty is also useful, since it makes the nest a soft and yet safe cradle for the young birds. In Bower-Birds, however, there is a very strong fondness for pretty things which are of no direct use. The beauty seems to be enjoyed for its own sake. Not only do the birds make bowers or arbours that are attractive in themselves, they decorate these in a charming way. The bowers are courting places; they are made long before the birds come together as mates; they have nothing to do with the nests, which are always built on trees and are quite ordinary constructions.

Bower-Birds are closely related to Birds of Paradise and not very distantly to crows. They often show handsome plumage, but they are not to be compared with the gorgeous male Birds of Paradise. They are forcible rather than melodious in their "song." What they lack in brilliance and music they make up for by the decorations of their bowers. There are many different kinds, but they are confined to Australia and New Guinea.

Let us begin with a simple case, that of the Saw-Billed Bower-Bird (Scenopoeetes). It clears a circular space around a tree, removing all the twigs, leaves and stones. Around the circumference it sticks in tendrils of a climbing palm, bending them inwards. Then it seeks for leaves that are silvery on the lower side and arranges them regularly on the cleared ground, with the bright surface up. Then the bird perches on the tree overhead, but every now and then it jumps down to replace a leaf that has been blown away or to turn up the silvery surface of one that has been blown upside down. In this case one promenade or playing ring is made by the male bird and another by the female, and this happens about a month before the mating. The female sits on a branch, quietly awaiting a visit from a suitor. The male energetically invites a call, for he gives utterance to an extraordinary song, consisting mainly of snatches borrowed from other birds, and even from insects such as grasshoppers and cicadas. He continues this all day except when he jumps down to strut about the ring or to replace a leaf that has become shrivelled. The birds often require to exert considerable force to get a leaf that they fancy separated from its tough stalk.

The arrangements made by the Satin Bower-Bird (Ptilonorhynchus) are more elaborate. The

The Satin Bower-Bird.

bird is about the size of a magpie, the male glossy purplish-black, the female chiefly greyish-green, and the two seem to make the bower between them. There is in the first place a sort of platform of twigs raised a few inches off the ground in a clearing. On this there is built an archway of twigs, sometimes open, sometimes closed, at the top. This arch or arbour may be several yards long, but it is just high enough to let the birds run about freely. It is often festooned with creepers. But there is something more, for in front of the entrance there is a "beauty-feast," namely, a miscellaneous collection of snail-shells, blanched bones, bright

feathers, and so forth, which are gathered from the country round about. An interesting point is that the birds, who are not in any hurry, spend a good deal of time in trying various arrangements of their spoils. The male chases his desired mate in and out of the arbour; he struts and bows and displays his fine feathers; both birds seem to be full of glee.

A recent observer describes the bower as like an arch turned upside down, open at the top, standing in a little glade, with ferns and shrubs forming a natural fence. Before the entrance there were bleached bones, some land-shells, several blue feathers from parrots, bits of blue glass, and about a score of flowers, chiefly violets. "To gather the blossoms the Bower-Birds must have visited a settler's garden, two or three miles from the scrub."

The Collared Bower-Bird.

In a clearing, sometimes under a beautiful bush of red Bougainvillea, the Collared Bower-Bird (*Chlamydodera nuchatis*) makes a long arbour raised on a low platform. They are soberly coloured grey-brown birds, except that they have an iridescent red-violet collar, usually more brilliant in the male. But what they lack in colour themselves they make up for by what they gather. In front of the arbour the ground is strewn with brightly coloured flowers, red berries of the Blue Gum, whitened skulls of small mammals, bright feathers from other birds, shining pods and shells. If they are near some deserted gold-digging settlement they may add to their display broken pieces of glass and even empty tins. They are evidently attracted by what is brilliant. We read that a museum specimen of the bower included more than half a peck of decorations. "They consisted principally of a large white univalve; the shell of a large land-snail, of which there were in all about four hundred; shining stones, principally flints and agates; bright-coloured seed-vessels and pods; bleached bones of small quadrupeds, and other objects of interest." The male bird struts about in the

Drawn by permission of the Natural History Museum, South Kensington.

THE COURTING PLAYGROUND OF THE ORANGE-CRESTED BOWER-BIRD.

This ambitious structure is not, as popularly supposed, a nest, but a courting playground, its romantic atmosphere being attained by lavish adornment with flowers, shells, and other bright objects.

show as if he got some reflected glory from his collection, and he becomes more and more excited. At last, for some reason best known to himself, he seizes a particularly fine object in his beak—it may be a leaf or a flower or a feather —and waving it aloft rushes at his playfellow with quivering wings and chases her in and out of the bower. By and by they go off together to build a nest in a tree.

In another kind of Chlamydodera the platform of interwoven twigs is four inches high, and the bower proper from sixteen to twenty inches. There are the usual decorations, including shells brought from the seashore some miles away. The male bird indulges in the usual showing off, dancing and jumping in great glee. In one case it was noticed that he carried about day after day a long dry reddish centipede, which had struck his fancy. He held it in his beak and waved it about as if it were a flag. It is very difficult to imagine what this kind of behaviour means, whether the bright object is a "symbol" of the bird's love, or is merely something to flourish about, like a cane. In the case of this particular Bower-Bird, as many as half-a-dozen visitors have been seen in the bower, but, again, we have to confess that we do not understand. One male holds the stage at a time, and in the long run the outcome is as usual, that a pair of birds fly off to a tree to nest.

Photo by permission of The Natural History Museum, South Kensington.

A PAIR OF CRESTED BOWER-BIRDS, showing the difference between the gorgeously crested male and the less decorative female.

In his interesting book, "In Australian Wilds" (1919), Mr. Charles Barrett describes one of the bowers to which we have just referred. "Beneath a straggling clump of boxthorn was the bower of a pair of Spotted Bower-Birds (*Chlamydodera maculata*). It was neatly and strongly built. At either end was a collection of bright objects—bleached bones, pieces of weather-worn glass, green and blue, some blue feathers, fresh glossy leaves, a few red berries, a bit of perforated zinc, and other odds and ends that the birds had gathered from far and near. Conspicuous among the Bower-Bird's treasures were five glass bottle-stoppers and a big pellet of lead. Through and through their bower the builders ran, tossing about the bones and other objects, and evidently delighting in the play."

Newton's Bower-Bird.

The *largest* bower is made by Newton's Bower-Bird (Prionodura), which arranges an arbour of sticks between two trees, and roofs in the space with creepers, embellished with white moss, ferns and flowers. It may be ten feet high and eight broad. The main bower has annexes of dwarf hut-like structures, but no one knows what these mean. There are many puzzles in the ways of Bower-Birds.

But the *finest* bowers are those of the Gardener Bower-Bird (Amblyornis), which differ widely in different species, but are always extraordinary. Dr. Beccari has given a good account of love's labour in the New Guinea Gardener (*Amblyornis inornata*), a plain, ruddy bird about the size of a thrush. This Bower-Bird chooses a spot centred in a small shrub towards a yard high. Around the base of this it builds up a cone of interwoven mosses, which may serve to strengthen the central pillar. It then takes the slender upright branches of a tree-orchid and arranges them like rafters with one end in the ground and the other on the top of the central bush. The result is a conical cabin, about a yard in diameter at the ground. The radiating,

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THE FLOWER-GARDEN OF THE GARDENER BOWER-BIRD.

This photograph, taken in New Guinea during one of the expeditions of that well known naturalist, the late Mr A. E. Pratt, is a remarkable illustration of the bower bird's artistic sense and skill. The bower, built of dead twigs and supported in the centre by a cone woven all round with an exquisitely fine hair like lichen, justifies us in calling the bird architect as well as gardener. The brilliant decoration is attained by little heaps of blue, yellow and red flowers, seeds and fungi, and here the male bird is shown about to add another ornament to the beautiful little arbour in which he dances and pays court to his mate.

almost straw-like rafters retain their leaves for a long time without their withering, as is often the case with orchids that grow as perched plants on trees. So much the better for the bower. But this is not enough. The slender rafters are bound together by more delicate twigs, and moss is added so that a well-made and beautiful roof is eventually formed. Between the base of the central pilaster and the insertion of the lower ends of the rafters in the ground there is a vacant space—the run—almost circular, in reality horseshoe-shaped.

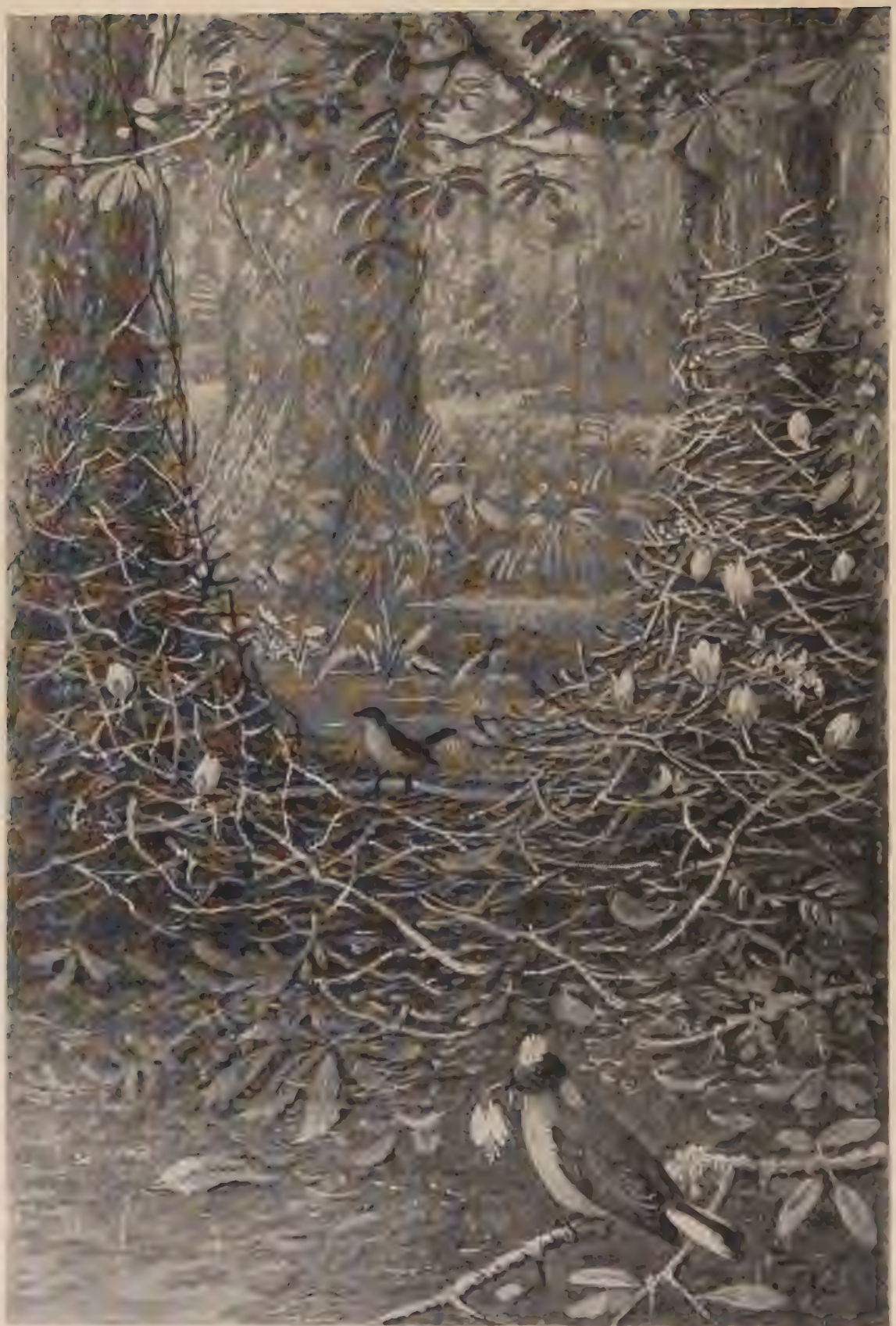
But this is not all. Directly in front of the entrance to the cabin there is "a miniature meadow of soft moss, transported thither, kept smooth and clean, and free from grass, weeds, stones and other objects not in harmony with its design. Upon this graceful green carpet are scattered flowers and fruit of different colours, in such a manner that they really present the appearance of an elegant little garden." The collection may include brightly coloured toadstools and insects, and some of these are strewn about in the interior of the cabin as well as in the garden. As is usual, everything that withers and shrivels is removed, and replaced by fresh material. The "garden" is often larger than the "cabin," and its meaning is the same. It expresses a pleasure in pretty things, and that pleasure has been linked on to love-making. The nest is just as usual—a simple affair on the branch of a tree.

The Dawn of the Æsthetic Sense.

What does it all mean? The making of the bowers requires time and energy and carefulness; the bright objects are often carried for miles; they are not scattered about anyhow, but experiments are made in their arrangement.

Perhaps we may draw two conclusions. The appreciation of bright things that is shown by jackdaws and some other members of the crow family reaches a high level in the Bower-Birds. They have the beginning of our own delight in the beautiful. But it is linked on to love-making. The exhibition of beautiful objects is used to express and to excite love, and is probably connected with the fact that the male Bower-Birds are rarely brilliant and never melodious. It comes to this, that the "beauty-feasts" are forms of art, expressive of love. In preparing them the birds are bound to one another by ties of feeling which last through their married life.

THE SATIN BOWER-BIRD'S PLAYGROUND.
This species has quieter and more refined tastes than its relative, the Gardener Bower-Bird, restricting the decoration of its bower to blue and yellow objects, such as shells. It has a strong aversion to anything red.



Drawn by permission of the Natural History Museum, South Kensington.

THE BOWER OF THE NEWTON BOWER-BIRD.

This rises to a considerable height and is built of twigs around the trunks of two trees close together. It is adorned with gaily coloured flowers, leaves, ferns and moss, and is the largest of all the bowers.

VI
EVERYWHERE THERE ARE FITNESSES

ONE of the charms of Natural History is the discovery of fitnesses or adaptations —particular adjustments of structure and activity that suit particular circumstances or needs. The insect-catching tongue of the Chamæleon that shoots out to a length as great as the distance between the fore-limbs and the hind-limbs is an adaptation. The valved doorway in the traps of the Bladderwort floating in the pond allows little water-fleas (small crustaceans) to enter, but prevents their escape. It is an adaptation. The trunk of the elephant, which is an elongation of the nose and of part of the upper lip, is well suited for grasping food and conveying it to the mouth. It is subtler than any hand, and a good example of a fitness. The angler or fishing-frog is a fish with an enormous gape, and it has been known to swallow a lythe as heavy as itself. The wide jaws are covered with long sharp teeth, which have this particular adaptation, that each is hinged at its base and yields before anything that enters. But if that thing tries to get out again, all the teeth rise up against it. With a dead angler stranded on the seashore, it is worth while making the experiment of pushing the hand into the mouth and then discovering how careful one must be in drawing it out again. The Venus Flytrap of the Carolina swamp is able to close its leaf-blade with considerable rapidity on an insect. When we look at the rat-trap-like teeth which interlock at the margin when the leaf closes, or at the three pairs of hinged sensitive hairs which respond to the touch of the insect's foot and pass on the news to the blade, or at the glands which pour out digestive juice inside the trap, we understand what an adaptation or fitness means. The five examples that we have given have all to do with the capture of food, and when we come to the chapter on Food-getting we shall see that these instances are only samples out of a multitude.

Photo: F. Russel Roberts.

A TWO-HORNED RHINOCEROS WITH SENTINEL BIRDS PERCHED ON ITS BACK.

These birds feed upon the ticks living on the hide, and in return, warn the rhino of the approach of danger. The common Rhinoceros-bird, or Ox-pecker (Buphaga), belongs to the Starling family (Sturnidæ).

Different Kinds of Fitnesses.

The old naturalists were quite alive to the presence of these fitnesses in plants and animals, but they did not realise that the whole creature is a bundle of fitnesses. There are remarkable instances and more commonplace instances; there are adaptations that strike the eye and others that do not meet the ordinary eye at all; there are adaptations hidden in the interior as well as those that show on the surface; there are adaptations before birth as well as in adult life; there are fitnesses of function or action as well as fitnesses of structure and architecture. In short, the whole organism is a bundle of fitnesses. If we look at a mole, for instance, we see its spade-like hand, its long snout, its barrel-like body, its reduction of friction, its well-hidden eyes, its sharp back teeth suited for crunching grubs —why, the whole animal is built up of fitnesses! If we take a bird's skeleton, which may often be found well-cleaned on the seashore, we may spend a day studying its fitnesses for a flying creature. Thus there is the keel on the breastbone, so well suited for the attachment of the lower ends of the muscles concerned in flight; there is the solidifying of the vertebræ along the back, which affords a strong fulcrum against which the wings can make their stroke; there is the reduction of mobility in the wing

PLANTS THAT HAVE BECOME ADAPTED TO USE INSECTS AS FOOD.

1. The Venus Fly-trap (Dionaea), which snaps together the two halves of its leaf when a fly alights upon its surface.

2 and 3. Two Pitcher Plants (Nepenthes and Sarracenia), having cups filled with a fluid which digests insects drowned in it.

4. The common English Butterwort (Pinguicula), its glistening leaf covered with a sticky secretion which detains insects and also secretes digestive juice.

5 and 6. Sundews (Drosera), which also spread a sticky trap for insects. The sensitive mobile tentacles of the leaves fold over upon their prey.

bones so that the wing moves *en bloc* when used in flight and yet can be folded up like a compressible letter Z when the bird is at rest; and, to take one other instance out of many, there is the lightly-built character of the skeleton, for the bones may be compared to hollow girders, very strong without being very heavy. When we come to discuss the movements of animals we shall see the multitude of ways in which the bodies of animals are adapted to different kinds of movements.

Many adaptations are rather adjustments of activity than adjustments of architecture. Thus, the hedgehog and the adder are inveterate enemies, and while we may find a special fitness in the transformation of many of the hedgehog's hairs into protective spines, there is a subtler fitness in the fact that the hedgehog is immune to the adder's poison. That is to say, the hedgehog's blood contains a counteractive (or anti-toxin) that keeps the poison from being fatal. Of course the hedgehog does not like to be bitten, and it behaves very adroitly so as to avoid this, or so as to make the reptile break its fangs on the spines, but even if the hedgehog were badly bitten it would not die. This is a chemical adaptation; it has to do with the activity of the blood-cells, which make the anti-toxin, rather than with any particular structure. Between the immunity and the spines, we might rank the hedgehog's habit of suddenly rolling itself up to avoid the bite of some enemy like a fox. For here we have to do with the strong development of muscles that roll the animal up into a ball, and also with the habit of doing this, and with the sensitiveness that pulls the trigger. When we come to discuss armour and weapons we shall see how multitudinous are the adaptations in thrust and parry.

Hedgehog and Adder.

Let us take another example of an internal fitness. Birds and mammals are warm-blooded animals in contrast to the cold-blooded reptiles, amphibians and fishes. Whereas the cold-blooded animals approximate to the temperature of their surroundings, the warm-blooded animals are able to remain always of the same or almost the same body-temperature, day and night, summer and winter—and this is a great advantage. When a mammal in very cold surroundings begins to lose

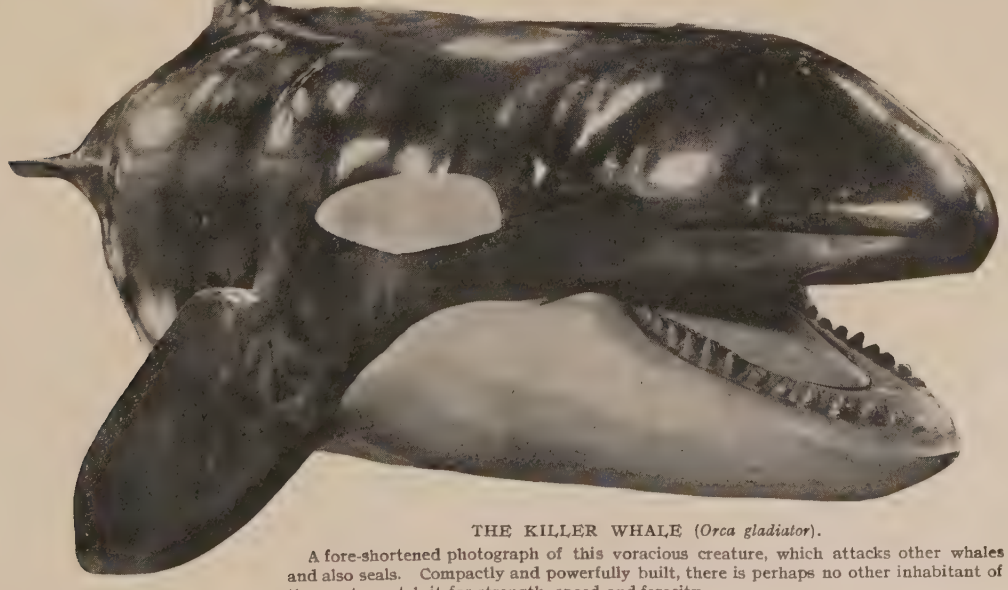
Warm-blooded Animals.

more heat than its muscles are making (they are the chief producers of animal heat), there is a narrowing of the blood-vessels in the skin, which lessens the loss of heat into the air, and orders come from the brain to the muscles commanding them to produce more heat. But the animal does not know anything about this, except that its momentary discomfort soon disappears. What is the chain of events? (1) The temperature of the blood falls a little because of the loss of heat on the very cold day. (2) There is a heat-regulating nerve-centre in the brain which is very sensitive to a change in the temperature of the blood passing through it. (3) The slightly colder blood automatically rouses the centre into activity and urgent orders are sent to the muscles, with the result that more heat is produced. At the same time, also automatically, nervous messages pass to the skin blood-vessels and these contract so that less heat is lost. These heat-regulating arrangements are good examples of internal fitnesses, which have been slowly perfected in the course of ages. It is interesting to notice that in nestlings the arrangements have not yet been adequately made, and if the mother-bird is unable to return to the nest, they will soon perish of cold.

The case just mentioned suggests another difference between the older Natural History and the new. The outstanding fitnesses which excited well-warranted admiration in bygone days were taken as arrangements given and finished. There was not much inquiry into how they *developed*, and there was no inquiry into how they *evolved*. But these two questions are always on the tip of our tongue. What were the chapters in the establishment of the fitness in the individual life-history? And it has just been noted that the nestling is not warm-blooded like the adult bird. When it is young it is lingering at the cold-blooded reptilian level; it has to climb up its own genealogical tree.

Fitnesses in the Making.

Even more interesting is the second question: how was this arrangement brought about in the course of history? Through what stages did it pass, and what were the factors that secured its increasing perfection? We may satisfy ourselves that warm-bloodedness did not appear right away in perfect adjustment, for a survey of mammals shows that some of them have only imperfect heat-regulation. This is very marked in the case of the lowest mammals—the duck-mole and the spiny ant-eater—which are almost reptilian in their changeableness of body-temperature. The spiny ant-eater may change its body-temperature 10°C. in a day, which would be quite fatal to us. As we shall see later on, those few mammals that are imperfectly warm-blooded tend to become winter-sleepers, like the hedgehog, or summer-sleepers, like the tenrec of Madagascar. They have made the best of their handicap by an adjustment of their



THE KILLER WHALE (*Orca gladiator*).

A fore-shortened photograph of this voracious creature, which attacks other whales and also seals. Compactly and powerfully built, there is perhaps no other inhabitant of the sea to match it for strength, speed and ferocity.

Photo: John J. Ward, F.E.S.

A FINE EXAMPLE OF AN INSECT FITNESS.
Just as the chamæleon has evolved a long tongue, so the not uncommon Ichneumon Fly (Rhyssa persuasoria) has developed a long ovipositor (seen projecting behind the insect), by means of which it places its eggs in the bodies of such grubs as that of—

habits. But our point just now is that they illustrate warm-bloodedness in the making.

As another example of the subtlety of internal fitness or adaptation, let us take the behaviour of a cat when it is surprised by a hostile dog. Everyone knows how it arches its back and how its hair stands on end, so that it looks twice its natural size. The dog usually finds it convenient to have business urgently demanding its attention elsewhere! The cat's behaviour is very effective, but the old naturalist was mistaken who supposed that the cat intentionally makes itself bigger in order to frighten the dog. That is not the true inwardness of the cat's behaviour. What happens is this:—

The Cat and the Dog.

The cat is emotionally excited, but it is not easy to tell what the emotion is. There is probably a good deal of anger in it, and not very much fear. The emotional storm is associated with nervous excitement in the brain, and a message travels by the (sympathetic) nervous system to a small glandular organ situated above the kidney, known as the supra-renal body. The message causes an instantaneous increase in the activity of the gland, and there is an increased production of a potent substance called "adrenalin," which passes into the blood. It is a chemical messenger or hormone. The results are almost magical: the blood pressure rises, the tone of the muscles improves, the amount of sugar in the blood increases, and also its clotting power. The minute muscles that are fastened to the sides of the moats or follicles in which the roots of the hairs are embedded, are brought into a state of contraction under the influence of the chemical messenger, and as the hairs stand on end we see the cat growing bigger under our eyes. Long before all this has happened, though it takes place very rapidly, the cat has sprung into an attitude of defiance—by a reflex action like that which we illustrate when we draw back our finger from a hot surface. But what we wish at present is some understanding of the fitness or adaptation by which, in the twinkling of an eye, the cat answers back effectively to an insult, and has its whole body prepared for a fight, if fight there must be.

Let us take two more instances of fitness or adaptation—one concerning structure and the other concerning activity or function.

An Extraordinary Egg-laying Organ.

The first has to do with an insect somewhat related to Ichneumon Flies (in the ant-bee-wasp order,

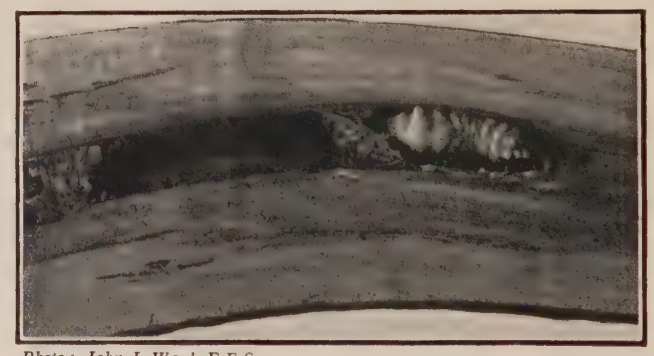
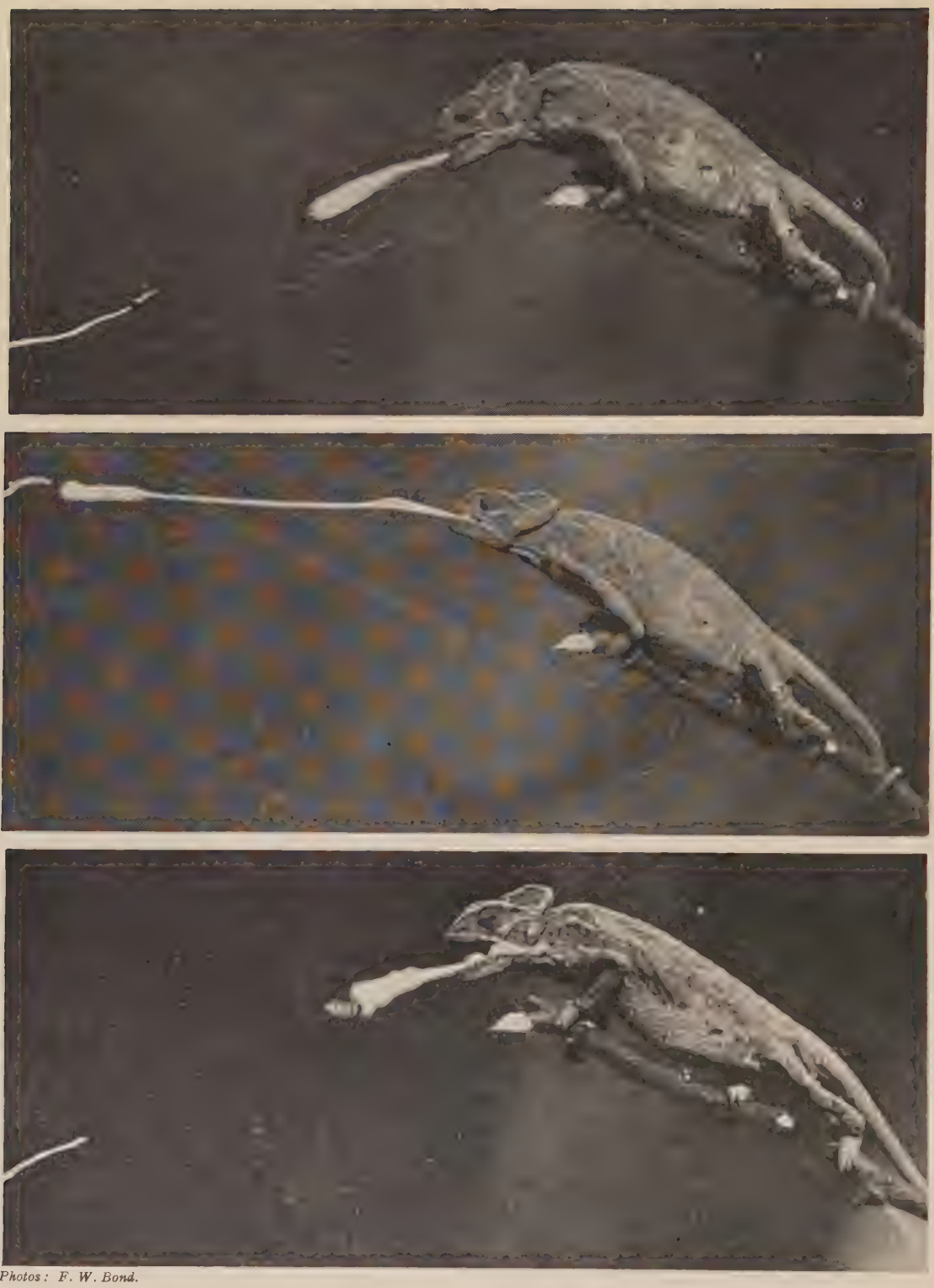


Photo: John J. Ward, F.E.S.

—the Lunar Hornet Moth, hidden deeply and apparently safe from harm in the heart of a branch.

Photo: Captain C. W. R. Knight. ONE MORE EXAMPLE OF A FITNESS OR ADAPTATION.

A green woodpecker clinging to a tree, with its strong claws. The tail is pressed firmly against the bark and acts as a support, whilst the bird pecks away in search of food.



Photos: F. W. Bond.

A PERFECT EXAMPLE OF ONE OF NATURE'S FITNESSES

The Chamæleon has evolved a tongue as long as its own body, the swollen tip of which is covered with a sticky secretion. By means of this long protrusile and retractile tongue, it whips up insect prey with amazing speed and certainty. (1) The Chamæleon in the act of extending its tongue to seize an offered insect. (2) Securing the tit-bit. (3) The insect, adhering to the tip of the tongue, being drawn back into the mouth.

Hymenoptera). The female lays her eggs in the maggots of certain midges, which in turn have the curious habit of laying their eggs in the sappy wood-vessels of the stumps of trees that have been cut down. We are not surprised to find that the female insects have long egg-laying organs (ovipositors), like borers, for this makes it easier for them to reach the midge-larvæ in the wood-vessels of the tree. The long ovipositor is in itself an adaptation, but this is not the point. One of the insects in question has a very remarkable horn open behind, which rises from the middle of the back and bends forward till it ends blindly on the top of the head above the eyes. This is a unique sort of thing and very puzzling. It is found in the females only, and a distinguished naturalist called Marchal discovered that it is a sheath for tucking away the exceptionally long egg-laying borer, which would otherwise be in danger of getting broken. It is a very remarkable adaptation of structure!

Photo: W. S. Berridge, F.Z.S.

THE SPINY ANT-EATER (*Prŏechidna*) OF NEW GUINEA.

An egg-laying mammal with some reptilian features lingering, such as imperfect warm-bloodedness. It is a powerful burrower, as its strong claws suggest. The mouth is quite toothless, and the sticky, worm-like tongue is used in whipping up ants and termites.

The Story of the Buoyant Barnacle.

Barnacles are marine crustaceans that start in life as free-swimmers but after a circuitous life-history, which we shall discuss later on, settle down on floating timber or even on a sea-snake's tail. They grow a long stalk from their attached head end, and the body comes to be protected inside five limy shell-pieces a little like the petals of a pea in their arrangement. But one kind of barnacle, which we may call the Buoyant Barnacle (*Lepas fascicularis*), attaches itself to light floating objects, such as a frond of seaweed, a feather, or a wooden match. For a time all is well, for the float is quite large enough to bear the weight of the barnacle. But as the barnacle increases in size, the float ceases to be adequate, and the barnacle begins to sink. This would be very disadvantageous, for sinking would carry the barnacle beyond the zone of the microscopic organisms on which it feeds, wafting them into its mouth with its six pairs of curl-like feet. What then happens in the case of the Buoyant Barnacle which has attached itself to a float that cannot be more than temporary? At the appropriate time it begins to secrete a buoy containing gas, and this is added to till it is large enough to serve as a float. The shell-valves contain very little lime in this species, so that the weight to be buoyed up is much less than usual. We do not know any finer example of an adaptation than the making of the barnacle's buoy.

VII

EVERYTHING IN THE LIGHT OF ITS HISTORY

THOSE who study plants and animals to-day have this great advantage over their predecessors before Darwin's time, that they look at everything in the light of history. Every complicated creature is the long result of time. Unless it is on the downgrade like a parasite, it sprang from simpler ancestors, and these sprang from others simpler still. The plants and animals of the Carboniferous ages, when the great coal-measures were laid down, were in many cases very complex and well-controlled organisms [or living creatures], but, on the whole, they were simpler than their descendants—the plants and animals of to-day. Thus, in those days there were not as yet any reptiles, birds, or mammals. In the course of ages, life has been slowly creeping upwards. There have been some slowly changing creatures; there have been others that have slipped down the ladder of evolution; but, on the whole, as the result of millions of years of changing and sifting, trying and testing, there has been an advance of life, something like what man calls progress.

Let us take a few illustrations of the historical or evolutionary way of looking at living creatures.

Pedigree of Birds.

There is convincing reason for believing that birds sprang from reptilian ancestors, active, high-strung, scaly creatures that ran swiftly along the ground and took running leaps on to the lower branches of trees. What evidence is there of this, for there seems little in common between the grovelling, cold-blooded reptile and the soaring warm-blooded bird? (1) The oldest remains of birds that are preserved in the rocks belong to a creature about the size of a crow, called Archæopteryx, whose skeleton presents many interesting features. There were teeth in both jaws, for instance, and no modern bird has even traces of teeth. There was a long lizard-like tail of twenty-six vertebræ (or backbone bodies), and no modern bird has more than a very short stump of a free tail, apart, of course, from the feathers, which do not count. There were three clawed fingers and the wing was what might be called half-made. Yet Archæopteryx was a genuine feathered bird. It is an historical relic, long since extinct, but linking the class of birds back to a dimly descried ancestry in the class of reptiles, in the order of Dinosaurs.

(2) Although there are great differences between every bird and every reptile, it is very interesting to find in the structure of birds numerous features, both big and little, which betray their pedigree. Thus all birds have some scales, especially on or near their toes, which are exactly like the scales of reptiles. And when we find that many birds, like the albatross, have what is called a "compound" bill, made up of a number of separate horny pieces, we may convince ourselves that these correspond to the scales on the jaws of reptiles. Such a little peculiarity as the annual shedding of the outermost covering of the bill in puffins comes to have a great historical interest, for it corresponds to the moulting of the outer covering of the scales in reptiles. On the other hand, the moulting of the bird's feathers marks something new, for reptiles do not moult their entire scales, to which feathers in a general way correspond; they simply moult the dead outermost layer of the skin which extends over the scales.

In many birds the front of the eye shows a ring of bone or a circle of minute bony plates (the so-called "sclerotic ossicles"), which strengthen the eye just where the transparent cornea (stretching like a blind over the front) joins the firm protective envelope (sclerotic) that extends round the back of the eye. This bony ring is not a very important feature, but it is seen in some extinct reptiles, and it is part of the bird's legacy from its reptilian ancestors.

(3) A third line of proof that birds sprang from a reptile ancestry is to be found in the study of development. It would be easy to palm off the eggs laid by many a reptile for those laid by birds. Thus the egg of a crocodile is not very different from that of a goose, or that of a tortoise from a pigeon's. If we break the limy shell of the two kinds of egg we find inside the same "white of egg" and the same sphere of yolk with a

Restoration by W. P. Pycraft, F.Z.S.

ARCHÆOPTERYX.

The oldest known bird, a fossil from Jurassic strata. This ancient bird had teeth in both jaws, a long lizard-like tail and a half-made wing. The skull is indicated at the foot.

little drop of living matter lying at its upper pole. For the first week or so, the development of the embryo bird, best known in the case of the chick, is very like that of the embryo reptile. It looks as if they progressed side by side along the same high road, until they reach a parting of the ways, when the one diverges to become a reptile, and the other to become a bird. In both cases the embryo is surrounded by the same birth-robes, the protective amnion which forms an elastic dome of fluid over the delicate young life, and another hood, the allantois, which has many blood-vessels and has mainly to do with *breathing before birth.* It is spread out underneath the shell, and its blood-vessels absorb oxygen through the pores. If the egg-shell be varnished so that the pores are closed the embryo bird or reptile must die of suffocation.

Another interesting point concerns the gill-clefts—minute slits which are seen on the sides of the neck in embryo reptiles and birds. There is no doubt that they correspond to the gill-clefts which are used in connection with breathing in fishes. They are openings from the pharynx (the muscular part of the food-canal immediately after the mouth-cavity). In fishes the water passes through them and they are bordered by the somewhat feathery gills on which the blood is spread out. But in all backboned animals above amphibians the breathing before birth is discharged by the allantois, the birth-robe already mentioned (forming part of the placenta in ordinary mammals), and the gill-clefts are of no use for breathing purposes. Indeed they do not seem to be of any use at all, except that the first one becomes the "Eustachian tube"—which leads from the ear-passage to the back of the mouth. Now the interest of these gill-slits is great: they are relics of the ancient fishes which were ancestral to all other backboned animals; they show how the past lingers in the present; and they are practically identical in embryonic reptiles and birds. In a few embryos of reptiles and birds a recent investigator has found in the gill-clefts several minute tags or filaments, which are almost certainly vestiges of the long-lost *gills.*

At the tip of the bill in the newly hatched bird there is often a whitish hardening of horn and lime which goes by the name of the "egg-tooth," though it has no connection with teeth. This hardening is used by the unhatched young bird as a hammer for breaking off the broad end of the egg-shell. The young bird, being ready to emerge, becomes restless; it convulsively straightens its head in a rather complicated way, and hits the inside of the shell. It shrugs itself a little, altering its position, and hits the shell again at a new place. If its strength lasts it may succeed at the first trial in breaking open the prison-doors; if it gets tired it will have to rest, perhaps till the next day. Here again we have an interesting structure—the egg-tooth. It does

As figured by W. P. Pycraft, F.Z.S.

THE WING OF THE HOATZIN (*Opisthocomus*).

The long thumb of this strange South American bird is clawed, also the first finger. The claws are used in climbing on the branches of trees, and the development of the hand-feathers is retarded.

its work well, but it is only used once in the lifetime, for it falls off a few days after hatching. But it is particularly interesting because it occurs in some reptiles, such as the crocodile. It is a trivial thing, but it is part of the legacy which birds inherited from reptiles. It is a straw which shows how the evolutionary wind has blown.

Many other examples might be given which prove the blood-relationship between birds and reptiles, but we have given enough to show what is meant by saying that every creature must be considered in the light of history.

The Whale's Relics.

Whales are very interesting in their structure and habits, especially in their manifold fitness for entirely aquatic life. But their interest is greatly increased when we study them in the light of their history—when we understand that they are the descendants of mammals that have returned to the sea after being for a long time at home on dry land, just as Loggerhead Turtles that live far out to sea are derived from ancestral terrestrial tortoises. Let us think of whales in the light of their history.

Deeply buried in the whale's flesh there are small vestiges of the hip-girdle and the hind legs. Of these dwindled pieces of skeleton it is safe to say that they are of no use. They are often called *rudimentary* organs, but it must be clearly understood that they are not beginnings of structures that might in the course of time become large and effective; they are dwindling, vanishing relics. It is extraordinary to find in a thirty-foot whale a piece of bone which corresponds to the thigh, and yet is not as long as our hand. What a contrast to the thigh-bone of the extinct reptile Atlantosaurus, which is six feet in length! But what is a whale doing with hind legs buried deep below the surface and useless? The only answer is that they are the dwindling relics of hind legs that were large and of use in the terrestrial ancestors. The whale's tail has become a *non-rotating* propeller, with the flukes as blades. In a seal, which is a carnivore, not a cetacean, the hind legs are not of use for standing on, and yet they are not vestiges. We see why this should be when we notice that they are turned backwards to form the chief propelling structures. They lie beside the short stumpy tail, which is not broadened into flukes like the whale's. In both cases, it may be noted in passing, a mass of water is displaced first on the one side of the hind end of the body, and then on the other side, in rapid alternation. The blades of the propeller are the flukes in the whale and the hind-legs in the seal, but in neither does the propeller go round. As we shall see later on, it is a *sculling* mode of locomotion.

Whales are practically hairless; they are covered with smooth slippery skin, well-suited for reducing friction in swimming. This is obviously very unlike a mammal, for the typical mammal is hair-covered. But the accepted fact that whales are transformed terrestrial mammals throws light on the abundant rudimentary hairs on many *unborn* whales. The past lives on. We also understand better the persistence of a few sensitive hairs about the lips of many a whale. It is surely an eloquent fact that a cetacean sometimes keeps just a few of its hairs in a strategic place, where they are of use as touch-structures, just like the whisker-hairs (or

Photo: C. J. King & Son, Scilly.

A LIFE-SIZE PICTURE OF THE PUFFIN'S HEAD.

The illustration shows the compound bill, made up of a number of separate horny pieces. During the annual moulting the outer covering of the bill is shed, a process corresponding to the moulting of the outer covering of the scales in reptiles, thus illustrating the reptilian ancestry of birds.

Photo : H. J. Shepstone.

A WHALE SPOUTING.

The spouting or blowing is the forceful expulsion of used air, and reminds us that the whale is not a fish but a warm-blooded mammal which breathes atmospheric air, whereas a fish breathes the air that is mixed with the water.

vibrissæ) on a cat's cheeks. Those touch-hairs of the whale's lip are often very richly supplied with nerve-endings (sometimes 400 nerve fibres to a single hair!), so that although they are remnants, they are far from being useless relics. But our point is simply this, that the whale's little moustache shines out when we turn on the light of evolution.

A whalebone-whale or baleen whale has no teeth in adult life. It rushes agape through the water and catches myriads of sea-butterflies (open-sea Gastropods) and other small fry on the frayed edges of the horny plates which grow down from the palate into the cavity of the mouth—sometimes to a length of seven feet! Every now and then the whale raises its tongue and swishes its multitudinous booty of jujube-like creatures into its gullet. It does not need teeth, and yet the remarkable fact is that it has two sets of them. But they never cut the gum; they are absorbed before birth. What a conundrum these two sets of useless teeth would be unless we knew that they are relics from past ages when the ancestors of whales lived on land and chewed their food.

We were at anchor late one summer evening in a fiord, where the stillness was complete. There were no breaking waves, no crying birds, and even the ship itself was as quiet as a mouse. All of a sudden just beside us a biggish whale spouted —there was an explosive burst as if of steam, and we dimly saw a pillar of breath and spray rising in the air. What is the whale's spouting in the light of history? The whale is a mammal, not a fish; it must therefore breathe dry air, it cannot in fish fashion make any use of the air that is mixed with the water. The toothed whales have to pursue their food in the depths. It is therefore advantageous that the acts of breathing should be reduced in number, since they must occur at the surface. The "blowing" is the forceful breathing-out of used air, and there are often several spouts in rapid succession. Then follow deep in-breathings, and the whale can store large quantities of air in its lungs (perhaps also in its blood) so that it can remain submerged for ten to twenty minutes. The spout consists mostly of the out-breathed air, plus water-vapour that may condense into drops in the cold, plus perhaps a little sea-water carried up. It may rise to a height of fifteen feet. These, then, are a few examples of the way in which the new Natural History looks at living creatures in the light of their history. Everything is an antiquity. The hand of the past is on the present—a living hand. Let us follow this clue!

THE STORY OF THE WATER SPIDER

An interesting example of adaptation is the way in which this species of the Spider family has become fitted for an aquatic life. The nest is built under water to avoid danger from enemies, but in order to make it habitable there must be an air supply. To meet this difficulty the spider weaves a domed web, thus constructing a diving bell, which she fills with tiny air bubbles. The bell or tent becomes more and more balloon-like, and in it the eggs are laid and the young reared.

The accompanying photographs by John J. Ward, F.E.S., show the spider in the process of air-storing.

1. The spider emerging from her under-water nest for a fresh supply of air.

2. Using the woven threads on the side of her nest as a rope-ladder.

3. Ascending a specially constructed thread to the surface, where she turns over—

4. And jerking out her body and legs, entangles some air.

5. Laden with a silvery bubble, she climbs downwards by her thread-ladder to the nest.

6. Entering at the base, she brushes off the air bubble, which ascends to the top of the silken nest.

VIII

THE HAND OF THE PAST

CHARACTERISTIC of the new Natural History is its appreciation of the living past. The hand of the past is upon the present, both for good and ill. This idea has been forced upon Natural History by the progress that has been made in the study of Heredity and Evolution; for heredity means the linkage between one generation and the next, both forwards and backwards; and the central idea of evolution is simply that the present is the child of the past and the parent of the future.

Everyone knows that we often carry about with us in our clothing trivial legacies from an almost forgotten past. There are buttons, used long ago for fixing upturned coat-tails, but the button-holes are gone. There are slits and buttons for fixing back the cuffs of sleeves, but they are rarely usable.

Similarly, in our body we carry about a museum of relics—legacies from the past which are of little significance to-day. Thus in the inner upper corner of our eye there is a remnant of the third eyelid, larger in some races than in others, a residue of what once was used to clean the surface of the eye. It is large in most mammals and of real service; it is a vestige in monkeys and man where the upper eyelid is unusually mobile. Similarly, there are dwindled muscles in the trumpet or pinna of our ear, which once were of use, as they still are in all mammals that cock up their ears. To locate the interesting waves of sound more precisely, the horse standing in the street moves its ear-trumpets without moving its head; but man moves his head in trying to "catch the sound," and this is one reason why the muscles in his ear-trumpet are usually nothing more than dwindled vestiges. Now and again, however, we come across a man who can make them move. These relics also illustrate the hand of the past upon the present, but it is not a very living hand.

We come nearer what we are working towards when we think of a familiar sight—the sleepy dog turning round and round on the hearth-rug. In its sleepiness there has probably reawakened the ancient habit of turning round and round in the herbage so as to make a comfortable bed for the night. It is probable that the living hand of the past is on the dog in front of the fire. Similarly, the horse that "shies" at a sudden rustling movement by the wayside, is probably obeying an ancient engrained habit of making a sudden movement to baulk a lurking snake or a crouching tiger.

The Dog Turning on the Hearth-rug.

But these are comparatively trivial illustrations of the big fact that living creatures are what might be called "antiquities." The past is living within them and it often expresses itself in a very useful way in situations where there is no opportunity for experiment. This engraining of the distant past forms part of what is called "the primary unconscious" in man. We wish to illustrate it in reference to what may be spoken of as "*the call of the sea*" in the case of newly-hatched Loggerhead Turtles, as investigated by Professor G. H. Parker, of Harvard.

Loggerhead Turtles are Open Sea reptiles of wide distribution, especially in the Atlantic. Two or three stray specimens have been captured on British coasts. They illustrate a return of reptiles from their present-day headquarters—the dry land—to the water in which their remote ancestors, the fishes, were at home.

The Call of the Sea.

About the month of July the mother Loggerheads bury their eggs in the sand, and after a few weeks the fully-formed youngsters emerge. What is particularly interesting about them is their inborn obligation to make for the sea. In some way, not very clear as yet, the past has been enregistered within them, and it pays to obey its promptings. Professor Parker writes: "To see a dozen of these newly hatched creatures, that have had no previous experience with the ocean, scramble toward it, notwithstanding that it may not be within their range of vision, is a sight never to be forgotten. To the observer they seem to be drawn toward the sea by an influence as mystical as it is impelling." But Professor Parker soon showed that it was not *mystical*, and it is very instructive to follow his experiments.

What he first did was to place a young Loggerhead in the middle of a paper-board about a yard square, surrounded by a fence about six inches high. He pointed its head north, but it went west. He took another one and pointed its head south, but it also went west. In short, they all went west—and the water and the afternoon sun were both in the west.

The next step was to shift to the opposite shore of the Florida peninsula, where the experiments were made. Here the water was to the east, of course, while the sun not unnaturally remained in the west. The young Loggerheads all went east, which proved that their movements were related to the position of the sea and not to the sun. When Professor Parker stopped in a field about midway between the two bodies of water, he found that the young turtles were as likely to go in one direction as in another. He was easily able to show, moreover, that whatever influenced them, it was not the sight of the actual sea, nor the sound of the sea, nor the smell or moisture of the sea. He also discovered that the young creatures like going downhill, and this will, on the whole, lead them right. But on the level they still made for the sea. *What was the directive influence?*

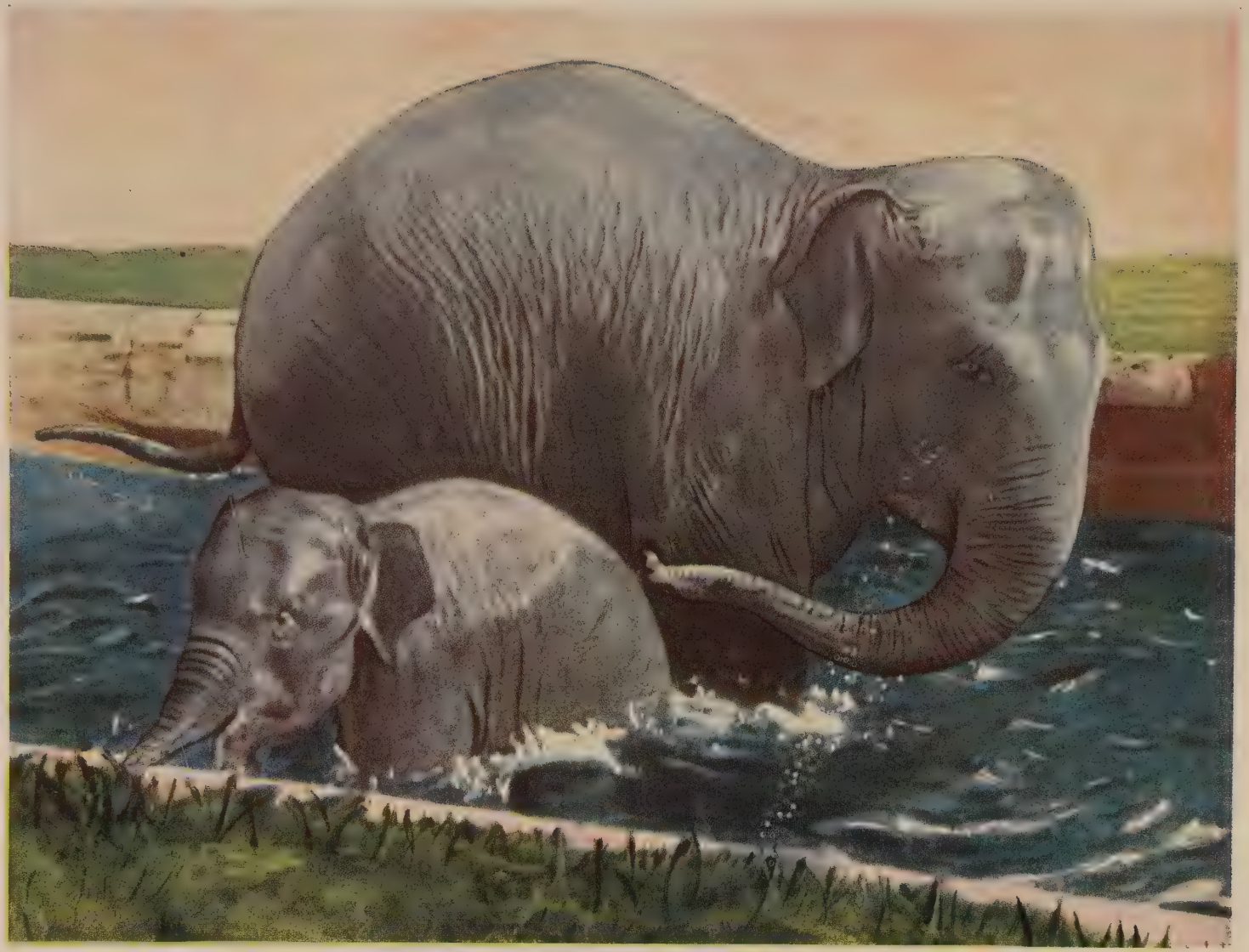
When the young Loggerheads were liberated in the pen in the darkness of night, they did not move towards the water as usual, but crept about in all directions. This showed that the directive influence had to do with sight. When they were put inside a deep tub from which they could see only the overhead sky, they failed to move in the direction of the sea, which showed that the directive influence was somehow connected with an all-round view. When they were placed on the bottom of an *inverted* tub, from which they could see all round, they moved first of all in a small experimental circle, and then directed their course for the sea. It soon became apparent that they made for the line of greatest openness. They looked all round and obeying the promptings of an ingrained hereditary impulse made for the more open horizon, which might often be in the line of most blue sky.

A very interesting point is that when a Loggerhead was started near a high shrubbery which intervened between it and the sea, it always moved away from the shrubbery and towards the open field. This was, of course, "wrong"; but it is the kind of exception that proves the rule. It showed that the call of the sea for the Loggerhead is the call of the open horizon. This is a very vivid illustration of the way in which the new Natural History must think of the living creature as a repository of history. The past lives on.

New York Zoological Society.

YOUNG OF THE NORTH AMERICAN YELLOW-BELLIED TERRAPIN (*Pseudemys*).

These, like the young of the marine loggerhead turtles, and, indeed, all their tribe, are hatched on dry land, yet at once make in the direction of the nearest water, in this case a pond or river.



"ENJOYING A BATHE."

IX

INSTINCT AND INTELLIGENCE AMONG MAMMALS

MANY well-known mammals have inborn powers of doing clever things, *which do not require any learning*. These inborn powers are called instincts, and they are not on the same line as intelligence. They are seen at their best in ants and bees, where the animal does a difficult thing the very first time it tries, and yet does not seem to understand what it is doing. In mammals and birds, however, the instincts seem often to be accompanied by some intelligent supervision, so that if there is a hitch in the proceedings, understanding is able to suggest a way out. This is very rarely seen in lower creatures—very high in their own way—like ants and bees.

§ 1

What, then, among the ways of mammals would be called *instinctive*?

Instinctive Behaviour.

The way in which a beaver cuts with its chisel-edged teeth all round the base of the tree till the breeze snaps the narrow core. The way in which a squirrel stores nuts for the winter, and the mole a collection of earthworms, each with its head bitten off. The way in which a harvest-mouse builds a neat nest among the stems of corn. The way in which a mother-hare leaps out of her "form" when she is going on an excursion and takes a long jump in again when she returns, so that the scent is broken and the cradle of her young ones is not betrayed.

Photo: Frances Pitt.

COMMON BROWN SQUIRREL (*Sciurus vulgaris*).

In its alertness, its nest building and its habit of storing against winter scarcity, this fascinating animal shows instinctive and intelligent qualities of a high order.

§ 2

Lord Avebury had a dog called "Van," which was taught to link together the sight of certain printed cards and some desirable experience. When it wanted a walk and saw that there was some chance of it, what did it do but go to the box of cards and select the one marked "OUT"! In other circumstances it would go to the box and select the card "TEA." But we must not be too generous in thinking over this kind of behaviour; the dog had simply learned to link together in its mind certain black marks and certain desirable things, such as a walk or a meal.

Linkages in the Mind.

Some dogs know without mistake what a particular kind of whistle means, and others link together the sound of a special motor-horn and their home-coming master. There was a setter that used to *say* "Don" when he was asked his name, and "Hunger" when he was asked what ailed him, and "Cake" when he was asked what he wanted. Visitors were much struck with the glib way in which

the dog gave the answers to those questions; but one day a scientific visitor arrived, and he began by asking the dog what ailed him, whereupon the dog said "Don." It turned out that the owners of the dog had always put him through his catechism in the same order. All that the dog had learned was that the first question must be answered by a sound more or less like "Don," and the second by a sound more or less like "Hunger." There was an association established, but in this case it did not seem to get beyond an association between certain answers and the *order* of the questions.

In many cases, however, dogs are able to distinguish the sounds of particular words and to link these to certain doings of their own. This is very important in Natural History, for some young animals in Wild Nature spend a good deal of time in learning to connect certain sounds in the woods with particular pieces of behaviour.

A bull-terrier called Jasper was carefully studied by Professor John B. Watson. From behind a screen the owner, Mr. Dixie Taylor, would say in a quiet tone of voice: "Go into the next room, Jasper, and fetch me a paper lying on the floor." Jasper would do this at once, and was only at fault when there were several objects in a row on the floor. For then he did not always bring the right one. He might bring a slipper instead of a newspaper. Down on the street, Mr. Taylor said to Jasper: "Go behind me and put your feet on the bicycle." The bicycle was about fifty feet behind Mr. Taylor, but the dog trotted immediately to it and did as it was told. The command to go and put its feet on a motor car about a hundred yards off was executed with equal readiness. The dog had been taught to do these things, and it recognised the sound of a particular word or of several words as the signal which it knew should be followed by a certain performance.

We do not profess to be able to explain all the wonderful things that performing dogs are said to do, but a large number of the wonders are covered by the word "linkage" or "association." In the course of tuition, the creature learns to do a particular thing when it sees or hears a particular signal.

§ 3

Many mammals are very quick learners, and people who do not know of the many lessons are

Photo: C. Reid,] [*Wishaw, N.B.*

AMERICAN GREY SQUIRREL.

Less shy than its British cousin, this species of squirrel now being acclimatised in Great Britain threatens to become a danger to forest trees. It is common in the London parks, where its playful antics are a constant source of delight.

Photo: James's Press Agency.

A TEAM OF HUSKIES IN THE ARCTIC.

The dog's intelligence places him in the forefront of clever animals and makes him pre-eminently the friend of man, who has no doubt improved his partner's wits. The use of the dog as a draught animal is illegal in Britain, but in Arctic America, for instance, it is invaluable in this capacity. A team of huskies, or Eskimo wolf-dogs, can pull a loaded sleigh fifty miles or more a day.

apt to be too generous in their admiration. Of course it is all admirable, but it is not always so clever as it seems. There was an elephant at the Belle Vue Gardens, in Manchester, that used to take a penny from benevolent visitors, put it into the slot of an automatic machine, and thus get a biscuit. But if it received only a halfpenny from the visitor, it used to fling it back with disgust. "How clever of it," people used to say, but every stage in the performance had been the subject of careful training. The elephant had its trunk patiently guided to the machine, and it required two or three months' schooling before it learned to distinguish between the penny that worked and the halfpenny that did not. A spice of intelligence there was, but not nearly so much as at first sight appeared. Some mammals, such as pigs, are much cleverer than they look, but there are many that seem to be more intelligent than they really are.

Clever Learning.

Many mammals, such as rats, show considerable quickness in learning to find their way into the centre of a labyrinth or maze. The animals are first accustomed to take their meals in the central chamber of the maze, and then they serve an apprenticeship to finding their way in. They learn best, naturally enough, when they have a good appetite. In the course of days they make fewer and fewer mistakes. They get rid of useless movements. Finally, in some cases, they do not make any mistakes at all.

Many interesting experiments have been made with a peculiar variety of mouse—the Japanese Dancing Mouse, famous for its whimsical habit of waltzing round and round, without any obvious reason. There is something wrong with its constitution, but what that precisely is we do not know. It is an animal that could not possibly survive in Wild Nature, but flourishes fairly well under man's protection. Its interest for us just now is that it can learn some lessons quickly. Professor Yerkes took the Dancing Mouse for his pupil, and one of the lessons was to distinguish between two pathways marked by different illuminations and different colours. If the mouse chose pathway A, it found a clear

passage to its nest; if it chose pathway B, it was punished by a mild electric shock and had to take a roundabout way home. In the course of time, the mouse learned the lesson perfectly, and went right into pathway A without making any mistake. It will be understood, of course, that precautions were taken so that there were no smell-traces to help the mouse. Moreover, the A compartment was sometimes to the right hand, sometimes to the left, else the mere position would have counted. What is clearly proved is that a mammal may learn in a short time to distinguish between comparatively slight differences in light and colour. This kind of learning is likely to be very useful in Wild Nature. For there is no doubt that clever mammals, such as foxes, are very quick to notice that some slight change has occurred—some new sound or scent, some new shadow or movement, which must be regarded with suspicion. This is at the root of what we describe as wary.

§ 4

Intelligent Behaviour.

We have seen that some of the mammals have inborn cleverness or instincts, and we have given examples of the way in which they learn to connect certain sights and sounds with certain actions of their own. But the most interesting question is: Do mammals think? Do they profit by experience in an intelligent way? Do they put two and two together so that we feel bound to say that they are understanding in some degree what they are doing?

When we watch collie dogs at a shepherding competition, where they are set problems such as bringing sheep back to the fold along a difficult path, or separating two flocks that have got mixed together, we feel inclined to be very generous. The dogs behave as if they *understood* what was wanted of them. We get the same impression of intelligent interest when we watch the ponies at a polo match. Many observers

Photo: Topical Press.

COLLIE DOG ROUNDING UP A FLOCK OF SHEEP.

In recognition of their usefulness, dogs tending sheep and cattle are exempted from tax in Britain. The collie and the old English bob-tailed sheep-dog are the two breeds usually chosen for the work, and the skill they display reaches a climax of animal intelligence. The young dogs are quick to learn, and their training is often left to an old veteran dog—sometimes the mother—experienced in the art of herding.

would agree with Kipling that a clever pony enters into the game and may help its rider intelligently. We have often watched a horse doing shunting work near a railway station, and have turned away convinced that if the behaviour is not intelligent, it is an extraordinary close imitation of the genuine article. The same may be said of the behaviour of the elephant helping the woodman in the Indian forest. In these cases—dog, horse, elephant—we are dealing with mammals endowed with very fine brains, and we need not be stingy. It has to be remembered, however, that they serve an apprenticeship and that they work in co-operation with man, which must help to excite their intelligence. Can we find other instances ?

In the beautiful " Zoo " in Edinburgh some of the large mammals live in old quarries, so that the visitors have the pleasure of seeing them against an interesting background of rock, and not through iron railings. A Polar Bear, when we saw it one day, was sitting on a promontory projecting into the water of a quarry. The kind-hearted visitors had thrown it buns, and many of these had fallen short and were floating on the surface. It would have been easy for the bear to have plunged into the water and secured them, but it was not so inclined. What we saw it do was of interest. It came to the edge of the rocky promontory and began scooping the water with its huge paw. This produced a current, and as the bear continued scooping skilfully, the buns came floating past and were captured. Of course we would not base any large conclusion on what we happened to see once, but it seems very likely that the bear's behaviour should be ranked as intelligent. The bear did in some way put two and two together—it used old means towards a new end.

A dog, carrying a basket of eggs by the handle, came to a stile ; it poked the basket through at the foot, ran back a few steps, took the stile at a bound, pulled the basket through and went on its way. A dog, afraid of the water, entered a *strange* boat to follow its master across a river.

Photo : Frances Pitt.

REYNARD ON THE WARPATH.

For cunning and strategy, the fox is perhaps unsurpassed, although the sly nature of his cleverness sets it at a far lower level than that of the dog. A member of the canine tribe, he yet has many attributes of the feline, not the least being his agility in climbing trees to get at the ripe fruit.

During a bad flood in a meadow near a river a number of mares herded their foals to the top of a hillock and kept them in the centre. These are instances of behaviour to which we should be inclined to grant the title of *intelligence*.

But we must turn again to Professor Köhler's chimpanzees (" The Mentality of Apes, 1925 "), for the observations were made with unusual carefulness, and the animals were kept in very wholesome conditions at Teneriffe. The results show that naturalists have hitherto underestimated the intelligence of these apes.

An animal of higher degree makes as directly as it can for a desired objective, such as food. But if the direct way is blocked by bars or other hindrances, it seeks for a roundabout way ; and we may judge of its intelligence by the nature and number of the trials it makes. Köhler's

From Prof. Wolfgang Köhler's "The Mentality of Apes," by permission of the publishers, Messrs. Kegan Paul, Trench, Trübner & Co., Ltd.

CHICA ON THE JUMPING STICK.

Professor Köhler's chimpanzees showed a high degree of intelligence in their open-air enclosure at Teneriffe. To reach tempting fruit hung high above its head, this one invented a jumping pole. It used to climb up, snatch the prize and then jump off before the pole fell.

chimpanzees were very quick to appreciate any such situation, as the following experiment shows. The objective was a heavy basket hung from the wire roof, but not reachable from the ground. A push made the basket swing for some time, and its longest swing to one side brought it within reach of a scaffolding. "Thus the roundabout way is easily recognisable, and available, but only for a few moments." The basket was set a-swinging and three chimpanzees, Chica, Grande and Tercera, were let in. Grande leapt directly from the ground and *missed*; but Chica, after quietly surveying the situation, clambered up the scaffolding, waited with outstretched arms for the basket and caught it successfully.

Grande did the same when the test was repeated, and every chimpanzee can solve this sort of problem, which seems, one would think, to require a spice of judgment.

A chimpanzee will pull in a distant object which has a string running from it into the cage, but if the string-end and the object are wide apart it will not usually try to pull in, unless it is interested in the string as such. An object may be pulled into the cage by using a stick; a banana out of reach may be captured by swinging vigorously on a rope; some fruit fastened to the roof may be obtained by pulling a box to the proper place and mounting on the top; sometimes a stick was used to eke out the vantage of the box.

In their school—it was at Teneriffe—the chimpanzees made many inventions, such as a "jumping-pole," which they climbed up and jumped off before it fell, a lever for breaking boxes and bolts, a spade for digging in the ground, and a stick for fighting with. Of course the apes were never taught anything; they were simply given opportunities of finding out for themselves. An interesting game was holding a slice of bread, which they do not much appreciate, through the bars for a hen and then drawing it back just before the peck came; or else letting the fowl peck and then prodding her forcibly with a stick or a wire held in the other hand. On a few occasions two of the chimpanzees fed the fowls with bread and watched the meal with great interest—but this was simply a play, certainly not "altruism."

When one of the chimpanzees was trying to reach a banana with a stick that was too short, it sometimes took another and shorter stick and laid the two in line so that the outer end touched the objective. This was of no avail of course, but it was interesting; and soon afterwards, being provided with two bamboo rods, one smaller and shorter than the other, the chimpanzee fitted the shorter into the longer, made

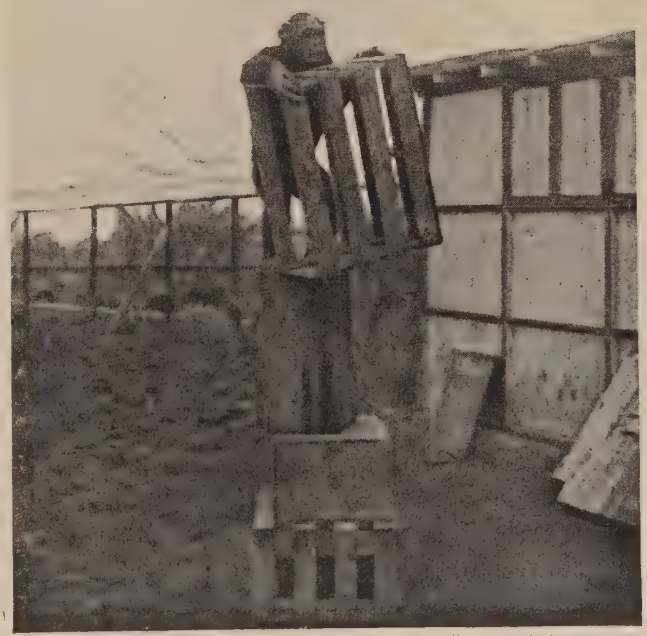
a double stick, and reached the objective. This was an achievement, and the invention was made in the course of a day's experimenting. Chance may have helped, just as it sometimes helps man, but the chimpanzee profited by the chance !

To reach a treasure fastened to the roof a chimpanzee will mount on the shoulders of another or on the top of a box. On one occasion when a box was pulled to the right place, the fruit was still beyond reach. The animal then jumped down, considerably out of temper ; it seized a smaller box and ran round the room, cursing and kicking. " He certainly did not seize the second box to put it on the first ; it merely helped him to give vent to his temper." But quite suddenly his behaviour changed ; he stopped making a noise, pulled the second box to the first, and lifted it on to the top. Sometimes rather shaky four-storey edifices were erected, and this reveals a real power of putting two and two together.

These are but a few samples of the highly interesting observations which Professor Köhler records in his valuable book. They prove considerable intelligence on the part of the chimpanzees, but it must be noted that there are many cases which show limitations almost as striking as the achievements. Chimpanzees are inventive when they get a visual grasp of the whole situation, but they are puzzled by an optical complication that a little child sees through at once. They seem to be handicapped by their slender capacity for " image-forming," and, of course, by their poverty of speech. But they are wonderful creatures, certainly not poor relations of whom to be ashamed.

Some people refuse to do justice to monkeys, being repelled by their resemblance to man ; and they do not take the trouble to understand clearly what Darwin taught in regard to man's pedigree. In the first place one must remember that monkeys and apes form a large order (Primates) of mammals with great diversity amongst themselves.

In particular, there is a great distance between ordinary monkeys and the anthropoid apes. But though the anthropoid apes come nearest man, it is not supposed that any living ape is man's ancestor. That is quite out of the question. What Darwin taught was that primitive tentative men diverged long ago from a stock common to them and to the anthropoid apes. This momentous divergence, leading on towards Homo, probably occurred not less than a million years ago. The anthropoid apes remained arboreal and not very progressive ; tentative men continued a terrestrial evolution, becoming more unique and wonderful. It is not in his ancestry that man can suffer loss of dignity.



From Prof. Wolfgang Köhler's " The Mentality of Apes," by permission of the publishers, Messrs. Kegan Paul, Trench, Trübner & Co., Ltd.

GRANDE ERECTS A FOUR-STOREY STRUCTURE.

Another of Professor Köhler's chimpanzees proved its mental powers by piling four boxes, one on top of the other, in order to seize a banana suspended out of reach.

FROLIC AND FUN IN A WOODLAND GLADE

The story of the woods has often its tragedies, but this story illustrates the side of comedy. Brer Rabbit finds a mother tern of the aggressive Arctic species nesting inconveniently near his burrow, and the tern equally resents the large flat-footed creatures who chase each other in too close proximity to her treasures. A remarkable series of photographs (copyright), by W. Bickerton, illustrates the comedy.

The male tern sees his wife safely settled on her eggs.

The villain of the piece appears, and the tern, as a result of previous experience, faces the burrow.

Still closely watching, she turns half away from Bunny, who is looking in rather a shamefaced manner at his offended neighbour.

Emerging fearlessly from his shelter, Bunny goes in search of food bringing back a large leaf—

and makes such a commotion that the tern protests vigorously with her wings. In doing so she dislodges a jar lid that happened to be there. This rolls towards Bunny and frightens him badly.

The screams of the mother tern bring the enraged husband on the scene. He walks right down into the rabbit's burrow, and gives him a piece of his mind.

X

THE STORY OF THE ELEPHANT

THERE is nothing in all the living world to-day that is in the least like an elephant. It is true that in many points his structure shows that he is distantly related to the other hoofed animals, and that he must have had a very far back ancestor in common with them. But in most respects he stands quite alone. His huge size, his straight, pillar-like limbs, his short neck, his enormous head carried almost horizontally, and, above all, his wonderful, elastic and sensitive trunk,—all these make a whole to marvel at, an animal that looks out of date in our modern world, as though he were a survivor of ages long gone by. And this, indeed, is what he is.

§ 1

The Elephant's Forerunners.

Elephants are now only to be found in the hotter parts of Asia—the Indian jungles, Ceylon, Sumatra and a few other islands, and in the wilds of Central Africa. But millions of years ago, long before man existed on the earth, animals very like the elephant wandered over the greater part of the

Photo: Herbert G. Ponting, F.R.G.S.

INDIAN ELEPHANT MOVING A HEAVY LOG.

The intelligence of the tamed elephant ranks next to that of the dog and some of the monkeys. Although it is usually caught full grown, its training period is complete in a few months, and once tamed, the elephant is ready to make use of its immense strength in man's service. The photograph shows an Indian elephant at work in a timber yard.

Photo: James's Press Agency.

THE MAMMOTH, ONE OF THE FORERUNNERS OF THE ELEPHANT.

A restoration of the mammoth (*Elephas primigenius*), once common in England and all Northern latitudes. Though cave drawings prove that the mammoth existed contemporaneously with man, it is to its remarkable natural preservation that we owe our present-day knowledge of this creature. Dying in the Arctic latitudes and becoming embedded in snow and ice, whole animals have been discovered and removed from their ice grave, which has preserved them for thousands of years. From these frozen remains we know that the mammoth was of the size of the Indian elephant, covered with brownish wool and longer black hairs, and had tusks of extraordinary length, in some cases reaching nearly eight feet.

Photo: F. W. Bond.

USING TUSKS AS WELL AS TRUNK.

The intelligence shown by the elephant in moving and piling timber seems to approach a human level. Obeying the spoken commands of its mahout with a remarkably ready appreciation, the great beast not only pushes the logs with its trunk, but uses its tusks along with this versatile organ to move the heavy weights from place to place.

Northern Hemisphere, and even lived within the Arctic Circle.

We know this from the abundant fossil remains that have been found, and from these, too, we have learnt something of the different forms that succeeded each other through the ages, from the time that the first forerunner of the Proboscis-bearers struck out on a new path, away from the common stock of the hoofed animals. " The fossils, so far as is known, show that the earliest forerunners of the elephant were small marsh-dwellers which lived on succulent food in the African region. They gradually increased in size without essentially altering limbs and body, but as their legs lengthened and their neck shortened, their face and chin became gradually elongated to reach the ground for browsing." At that stage the tusks were in the lower jaw, and were apparently used for grubbing in the earth. The neck then, as now, had to be extremely strong, and therefore was too short to admit of the animal reaching the ground, and this lengthening out of the lower part of the face was one of the first ways of solving the difficulty of feeding. But as time went on Nature found a better way.

The chin shrank, the tusks developed in the upper jaw, and those in the lower jaw became less and less prominent, till finally they were only seen in very young animals; the snout began to lengthen out, and at last the trunk was fully developed. The stages through which the trunk passed can only be guessed at from the changes in the skull, for soft parts are rarely preserved as fossils.

As ages passed—long, long ages, for " they say it must have taken two million years for the lower tusks to wear away "—we come to forms very like our own elephant. Most of them were as large as, if not larger than, the modern elephant, but the remains of an interesting race of " pigmy " elephants, many of them no larger than a sheep, have been found in the islands of Malta and Cyprus. These, we are told, are probably descendants of some larger forms that were stranded on the islands when some

geological change cut them off from the mainland, and in the restricted space with limited food supply their stock became gradually smaller, as island-animals—witness the Shetland pony—are well known to do.

The prehistoric form of elephant about which we know most is the Mammoth, for it lived on long after man had appeared upon the earth. Not only are its remains found along with those of primitive man, but pictures of it have been found on the walls of caves, and carved by man's hand on the ivory of its own tusks. The mammoth was of the size and type of the Indian Elephant, but it was covered with a thick coat of short reddish wool, interspersed with long black hairs. Its bones and teeth have been found all over England, the north of Europe, North America, and in the remotest islands of the Arctic seas. Indeed, "the farther north we go the more numerous they become." So abundant are the heaps of bones and teeth that a trade in fossil ivory has been carried on for more than two centuries, for the mammoth bore a fine pair of large curved tusks.

In addition to these heaps of remains, several whole animals have been found in an upright position well below the surface of the ground, as if they had sunk bodily into a marsh, or been suddenly overwhelmed by a landslide. The frost of these regions has preserved the animals all these thousands of years, so that flesh, skin, and hair are all intact, and in one or two cases even the last meal of grass or pine-shoots was still fresh in the stomach.

The mammoth has long since died out, but the elephant, which existed along with it, holds its own still. How has it been able to survive so long? Perhaps if we look at it for a little in its native surroundings we shall find at least part of the answer to that question.

§ 2

There are two kinds of elephants, the Indian or Asiatic, and the African. The Indian form is the smaller of the two, but a full-grown male

Photo: Wiele.

MASSIVE STRENGTH.

In clearing away forest-trees in the course of road-making and the like, the elephant has proved invaluable. The photograph shows a highly trained animal using his great bulk and enormous strength to bring down a tree.

Photo : Wiele.

WILD ELEPHANTS IN THE KHEDDAH.

In order to capture wild elephants a large enclosure, called a kheddah, is constructed of stakes and heavy cross-pieces, and into this the herd is driven by an army of natives. Tamed female elephants, or "decoys," now enter the enclosure and help to hold their wild relatives while being secured with ropes. a further illustration of the elephant's keen intelligence. So clever do these decoys become that their work is achieved almost without any commands from their mahouts; in fact they look as if they derived enjoyment from the task and had an understanding of what is required of them.

stands from 9 to 11 feet high at the shoulders. His great body is covered with a thick, much-wrinkled skin, with only a few sparse hairs. The folds of the skin afford a favourite feeding-ground and hiding-place for many insects, and the elephants are very often seen with insect-eating birds on their backs. The birds get a comfortable living there, and the elephant tolerates their presence for the comfort they give by relieving him of his parasites.

The Indian Elephant.

The elephant's neck, as we have said, is very powerful, but so short that it gives no great range of movement to the huge head. The head must be strong enough to bear the weight of the heavy tusks, and have a large enough surface for the insertion of the great muscles needed to move the trunk. The elephant often uses the bony part of the head above the trunk to push things over, or as a kind of battering ram, and the reason that he can do this without hurting himself is that there is a very large space, more than a foot in extent, behind the strong outer layer of bone, which is entirely filled with a network of air-spaces separated by very thin bony plates. Similar air-cells are found in the bones of the nose and jaw, and they all communicate with each other, and ultimately with the nostrils, so that air can penetrate into them all. Thus the enormous head is not so heavy as it looks, and it is not at all a vulnerable part of the animal, for a bullet aimed at the forehead simply loses itself almost harmlessly in the labyrinth of air spaces, and never reaches the brain at all. The brain is larger than that of any other animal, living or fossil—even the whale.

The " milk " front teeth or incisors of the young elephant are shed at an early age, and their place is taken by the tusks which go on growing throughout life, and often reach a very large size in the male. Those of the female are shorter and less curved. The tusks are made of fine elastic " dentine," with just a tip of enamel which is soon rubbed off. The dentine is the valuable ivory of commerce. The elephant uses

Photo: Wiele.

RESISTING DISCIPLINE.

The photograph shows a recently captured elephant, partly roped, during its course of training. Disliking the irksomeness of discipline, the great beast is resisting being led by pressing its huge head against a tree.

Photo: Herbert G. Ponting, F.R.G.S.

BREAKING UP A RAFT.

The heavy logs from the forests are floated down the rivers in the form of a raft. On reaching the mills the rafts are broken up and the logs hauled ashore by elephants, a task particularly to the liking of these great beasts, who are very fond of working in the water.

his tusks for many purposes—rooting up plants, piercing or holding down an enemy, or supporting a heavy weight held in position by the trunk. Yet he is always careful to keep them from getting broken.

But it is the trunk or proboscis that gives to the elephant its chief distinction. This wonderful organ is a prolongation of the nose, which however, takes in part of the upper lip. It is a long straight tube, divided down the middle, very elastic and mobile because it is made up of rings of muscle, very sensitive because it is well supplied with fine nerves. The upper part ends in a finger-like projection, " which rivals in delicacy the trained fingers of a blind man." The elephant's trunk serves all the purposes of a hand, an arm, and a lip as well. With it he tears up the juicy plants on which he loves to feed, and puts them into his mouth, or breaks down the branches of the trees and strips them of their bark and leaves, or trims one into a fan, which he uses to drive off the flies that torment him ceaselessly by day. With it, too, he drinks, filling it with water, curving it round, and squirting the water into his mouth.

The upper part of the elephant's leg is long, so that the " knee-joint " is low down. The bones of the feet are short and stumpy. There are five toes, fore and hind, but they are so firmly wrapped about with fibres and sinews that they cannot move independently, and there is no sign of them on the outside except the ends of the hoofs or crescent-shaped nails which surround the tip of each toe. This great foot, which " has the appearance of an enormous pavior's beetle with a broad, flat undivided sole," gives the elephant its noiseless tread, but also furnishes it with a very formidable weapon.

§ 3

The home of the Asiatic Elephant is in the great jungles along the foot of the Himalayas, and elsewhere throughout India, the Malay Peninsula, and some of the larger islands. They

live usually in family parties of twenty to forty, but sometimes several such herds unite together for a time. The herd is under the leadership of an old "tusker," to whom the rest yield unquestioning obedience. The females and young ones lead the way in marching, and the males bring up the rear. Many of the adult males live alone except during the mating season, but sometimes a male tries to assert himself, and seize the leadership of the herd. Unless the old leader has become feeble he rarely succeeds, and is usually driven forth altogether. No other herd will admit the stranger, and thenceforward he leads a lonely life as a "rogue." Such rogues become very ill-tempered as time goes on, and are often very dangerous.

The Elephant at Home.

Those living in herds in the normal way are very peaceable among themselves, and towards other animals and man, whom they rarely attack. "Nature," says Mr. Lockwood Kipling, "in furnishing the beast with a soft and tender trunk has bound him down to keep peace with all creation." When the elephant does charge he carries his trunk tightly coiled up, and takes great care to keep it from being injured, for he cannot live without it, and "though protected by a pair of sharp bayonets, it is as vulnerable as a garden slug." No animal will venture to attack a herd, and even a tiger is scarcely a match for a single elephant, unless he can manage to avoid being pinned down by the tusks or trampled under the relentless hoofs. Elephants are wholly vegetarian, and, though they have their favourite food-plants, nothing in the way of grasses, leaves, or even young branches comes amiss to them. They do very serious damage by trampling and uprooting when they get into a plantation, and the Indians have to keep constant watch over their rice-fields. They build a high, strong platform near them, and two men keep watch in turn. If elephants approach the men shout, beat drums, and make all sorts of noises to scare

Photo: James's Press Agency.

A CAPTIVE BABY ELEPHANT BEING FED.

From its earliest days the baby captive is fed by the attendant from a bucket of milk, a process which makes the young animal familiar with mankind. The photograph shows how the height of this baby, about six months old, compares with that of man.

Photo: Wiele.

WILD ELEPHANTS IN THEIR NATIVE STATE.

The posting of sentinels and the herding in large numbers in the impenetrable depths of the forest ensures for the wild elephant a high degree of safety even from man. In addition, the elephant has keen senses of smell and hearing, and although he makes the forest resound with his loud trumpeting when he is feeding, he is able to move with a silence and rapidity astonishing in so ponderous a creature.

them away. This succeeds well enough with the cautious herd, but a " rogue " is not so easily frightened, and he will return night after night.

The herds never remain for long in one place, for they so quickly devastate a feeding-ground that new ones have to be constantly sought. They usually march after dusk, and they may go far up the mountain sides even when it is cold. They climb very skilfully and carefully, the leader testing every rock and tree-trunk, the rest following in single file. A fall is a serious matter for an animal of such enormous bulk, so their caution is fully justified. Whether in the plains or on the mountain sides, the one thing that seems absolutely indispensable to them is abundant water for drinking and bathing. Herds often stand up to their necks in water for hours during the hottest part of the day, and, if they cannot find pools deep enough for that, they fill up their trunks repeatedly with water and squirt it over their backs and sides.

The elephant's usual movements are ponderous, and a herd feeding in security makes a great deal of noise, but they can retreat without a sound if they are alarmed. The pace is slow, but so steady that great distances are covered in a night. An elephant can run for a long distance at ten miles an hour, and for a short distance much faster than that. He is a powerful swimmer and a herd will cross a broad river, swimming for several hours at a time, with only the tip of the trunk above water.

A female elephant usually has one calf every two years. The baby is just about three feet high at birth, but growth continues for about twenty-five years. It sucks with the mouth in the usual way, keeping the trunk folded back. It is said that any elephant mother will give suck to any calf in the herd, and there is no doubt that the young ones are kindly treated and caressed by all the members. The calf is precocious and able to move with the herd a few hours after birth. At first it walks in front of the mother, who guides it by laying her trunk along its back, but as soon as it has gained a little strength it runs under her body, and for a long time it retreats there on the least alarm. In swimming, the mother at first supports the young one with her trunk, but later, it is said, carries it more conveniently on her back.

§ 4

The African Elephant.

The African Elephant is a good deal larger than his Asiatic cousin ; his ears are much larger, his tusks heavier and rather more curved, and his trunk bears a finger-like projection below as well as above. The African Elephant has not been made use of by man since the time of the Cæsars, when it was much used in war and pageantry, and therefore it has not had the same measure of protection as the Indian Elephant now enjoys. So there has been little check on the killing of him for commercial gain, and his numbers are said to be fast diminishing. The favourite food of the African Elephant consists of the tender

OTHER TRUNKED MAMMALS

Not every creature that has a trunk is a relative of the elephant. The accompanying pictures show trunked mammals of widely differing types, which have developed a proboscis for protection or for feeding.

1. The Jumping or Elephant Shrew (*Macrosceles*). An African animal of the shrew family, which uses its slender trunk to probe the holes in ant-hills in search of insects.

2. The Malayan Tapir, a relative of the horse and the rhinoceros. This pig-like mammal has developed a short protecting trunk or proboscis.

Photos: W. S. Berridge, F.Z.S.

3. The Sea Elephant (*Macrorhinus leonina*). Found in Arctic regions, the full-grown sea elephant, a relative of the seals, has a peculiar trunk-like elongation of the nose, which is usually limp, but can be distended in excitement.

branches of the mimosa. But the mimosa grows very tall, and he cannot reach the branches with his trunk, therefore he uproots the tree. It is quite certain that some of the uprooted trees are too large to have been dealt with by a single elephant, and that they must have been brought down by the combined strength of several giants.

§ 5

Survival of the Elephant.

We may now return to the question as to how an "old-fashioned" animal like the elephant has been able to survive so long. Part of the answer lies in its structure, which we have already considered, and in its perfect adaptation to the surroundings in which it lives. Its gregariousness is a point in its favour, too, for a compact herd with sentinels posted to give warning at the slightest unfamiliar sound has nothing to fear except from man and the weapons of civilisation. And even from these relative safety is secured by the denseness of the forest in which the elephant lives, for it is hardly possible to penetrate into the interior of many parts of the jungle in Ceylon and the forests of Central Africa, except by means of the paths the elephants themselves have made.

Perhaps the chief reason for the elephant's survival, however, is to be found in his big brain, and the intelligence associated with it. He has very keen senses; his hearing and sense of smell are very acute, and his vision is good, though the field is limited. Yet many different opinions have been expressed as to his cleverness, that is, in the sense of being able to cope with unexpected circumstances. There is no doubt that a herd of elephants show much more intelligence in their ordinary life than any of the other gregarious vegetable-feeders, such as deer, for, though these follow a leader, post sentinels, and detect every unusual sign or sound, they never combine to attain some end as elephants are known to do. But in wild life the elephant does not behave so intelligently as the great Carnivores. This, however, is largely due to the difference in their mode of life. A vegetable-feeder, which can always find its food without difficulty, and must spend a great part of its time eating, because so much is required, has not the same need to develop cunning and

foresight as the large flesh-eating animals, whose life depends on their skill in hunting.

The outstanding feature in the elephant's mental capacity is its teachableness, and it is in association with human beings that its cleverness is fully developed. It has long been admitted that the tamed elephant shows more intelligence than any other animal except the dog and some monkeys. But a recent authority who has had great opportunities for observing elephants, both wild and tame—Dr. Hornaday, Director of the New York Zoological Park—refuses to allow even the dog a higher place. He points out that the dog, which is allowed to roam freely indoors and out, has quite different opportunities from the elephant, which, because of its size, must always be caged or tied, and be led wherever he goes. Moreover, dogs are trained from their earliest days; it is no use trying to teach an old dog tricks. The great majority of tamed elephants, on the other hand, are caught when they are already mature, yet in a few months they have learned to obey many commands, and to remember a long series of actions. They have also good memories for people, and are capable of strong attachment to their masters, and recognise them after a long interval, while they will revenge themselves for any injury or unkindness long after it has been inflicted.

Dr. Hornaday tells us of an interesting use made by a small and very young African Elephant of its eighteen-inch-long tusks. He was being forced on to platform-scales, and was greatly alarmed by the trembling of the platform. He backed, trumpeted, and refused to move, but it was all of no avail against the steady pushing of the keepers. Finally "he fell upon his knees and drove his tusks into the ground, quite up to his mouth, to anchor himself to solid ground." Having once discovered this trick, he used it often when he did not want to be taken back from the exercising ground to his own quarters.

The elephant, though he is of great use to man, cannot be called a domesticated animal. Young ones are only rarely born in captivity, and their period of growth is so prolonged that it is easier to catch wild elephants to keep up the supply than to try to breed them. The method of capturing them by driving them into

EVOLUTION OF THE ELEPHANT

From fossilised remains we know that the earliest forms of elephant were short-legged creatures, which in the course of countless years grew in stature. The trunk correspondingly developed to allow the animal to browse. Three stages of the process of evolution are here shown.

1. Restoration of Moeritherium, an animal about three feet in height.

2. Restoration of Palæomastodon, height from four feet to six feet, according to species.

Photos: E. J. Manly.

3. Restoration of Tetrabelodon angustidens, about the size of an Indian elephant; with four tusks.

a kheddah or enclosure surrounded by stakes and then securing them with the aid of decoy elephants has often been described. "The conduct of the tame ones during all these proceedings was truly wonderful. They displayed the most perfect conception of every movement, both of the object to be attained and of the means to accomplish it. They manifested the utmost enjoyment in what was going on. They saw intuitively a difficulty or danger, and addressed themselves unbidden to remove it. On one occasion when successive efforts had failed to put the noose over the foreleg of an elephant which was already secured by one foot, but which wisely put the other to the ground as often as it was attempted to put the noose under it, I saw the decoy watch her opportunity, and, when his foot was again raised, suddenly push her own leg beneath it and hold it up till the noose was attached and drawn tight." The captured elephants can usually be trusted to work without the company of a tame one after four months. The females alone are used for Government work, because of their greater evenness of temper, but males are also caught, and are sold to merchants or to native princes, who value them highly for purposes of display. The "white elephant" or albino, which is light in colour though not white, is especially sought after.

Where roads have been made the elephant has been largely displaced by motor traction, but over rough and hilly ground it is still greatly used as a pack animal. It is also much used for piling timber, and it is said that trained elephants do this with the same precision as dock labourers and with greater rapidity. In clearing the ground of bushes and undergrowth, too, they are exceedingly valuable, and they played an important part in making many of the tea plantations of India.

XI
THE STORY OF THE OTTER

AS another illustration of the ways of mammals let us take the otter (*Lutra vulgaris*). It is still fairly common in Somerset and Devon and the Lake District in England, and is also found in some parts of Wales, Scotland, and Ireland. It has a near relative in Canada and the United States. The wonder is that it holds its own as well as it does, for man's hand is strongly against it because of its fine fur. It is a very ancient inhabitant of Britain, for its remains are found as *fossils* in what are called later Tertiary deposits before the Great Ice Ages.

§ 1

The Otter's Place Among Mammals.

The otter is one of the Carnivores, and it belongs to the "Bear tribe," along with stoat and weasel, pole-cat and badger. But it differs from all these in having become aquatic. It has not gone so far in that direction as seals have, and not nearly so far as porpoises, which have become independent of the land altogether, but it has become thoroughly at home in the water. In the north of Britain it often lives in caves by the sea, and it may swim out to islands far off the coast. But it is not to be confused with the very rare Sea-Otter (*Latax lutris*), which is now restricted to some islands of the North Pacific. The true Sea-Otter is only a distant relative of the Land-Otters, and it does not come ashore except for short intervals and for breeding.

§ 2

Adaptations to Aquatic Life.

One of the interesting features in our Land-Otter is that it has become very much at home in the water—both fresh and salt—without losing its efficiency on land. It may travel fifteen miles in a night, and it makes long excursions in search of good fishing.

How is an otter fitted or adapted to life in water? It has webbed feet; the very muscular tail is a strong rudder; it has astonishingly good "wind," and is thus able to remain for a long time immersed. It is interesting to see an

Photo: F. W. Bond.

THE COMMON OTTER (*Lutra vulgaris*).

The otter is still common in some parts of our country, owing to its wonderful endurance and resource, as well as to its muscular development and the careful nurture and instruction of the young.

otter entering the water without making a splash, and to see it come out again—almost like a different animal. It looks distinctly smaller, for the glistening outermost layer of wet fur clings closely to the body and compresses the dry under-fur. We see, then, what a muscular animal the otter is; it has fine "streamlines," like a yacht, well-suited for rapid movement through the water. The otter is an athlete.

It often swims horizontally near the surface, making little in the way of ripple, and then, all of a sudden, it dives, often in a spiral, and reappears with a fish in its mouth. A small fish may be swallowed in the water, but an important capture must be carried ashore or lifted on to a projecting rock. In swimming near the surface the otter uses both fore and hind feet, which are webbed as well as clawed. But in pursuing its prey beneath the surface or in deep diving the fore-limbs are said to be the only parts used, the hind legs being turned backwards in seal-like fashion. As we have mentioned, the broad tail is used as a rudder. Mr. Tregarthen, who has studied this animal all his life, has given us in his "Life Story of the Otter," an account of its swimming and diving, its games and gambols. This is all the more welcome because most people do not get more than tantalising glimpses of the otter. It is one of those animals that are always disappearing; it effaces itself in a moment. Moreover, it does most of its hunting and roving by night.

§ 3

The Otter's Food.

In the main a fish-eater, fond of eels, trout, salmon, pike, flatfish, and so forth, the otter has *a long bill of fare*, and that helps an animal to hold its own. If it cannot get one kind of food, it tries another. Thus if the otter cannot catch fish, it condescends to eat mussels on the seashore, biting through their shells. It will even knock limpets off the rocks, and it will crunch up big land-snails. On another line it catches frogs in the marsh, or wild-duck by the lake-side, or

Photo: Frances Pitt.

OTTER CUBS AT BREAKFAST.

The cubs are shown enjoying a delicacy provided for them by their most careful and solicitous mother.

rabbits on the links. All is grist that comes to the otter's mill.

The otter has excellent teeth, and the socket in which the lower jaw works is very deep and strong. This gives it a very tenacious grip, well suited for keeping hold of a struggling eel or pike. Like many another carnivore, the otter is apt to kill more than it needs if a good opportunity occurs. This is not "greed"; it simply means that the inborn impulse to kill is irresistible. It seems to enjoy a draught of blood when its appetite for flesh has been satisfied.

Many carnivores go back to the "kill" which they have left unfinished, but the otter rarely does so. It is not likely that the creature thinks this out; it is more probable that it feels instinctively that danger lies that way. Similarly, it often seems to avoid retracing its steps or making a definite track. Moreover, its scent soon disappears when the sun rises.

§ 4

Here, then, is a large-sized mammal still keeping its foothold in a very unfriendly country. How does it manage it? Let us add up what we have seen.

How the Otter Holds its Own.

The otter has reduced both its enemies and its risks by becoming aquatic; it has lessened them again by becoming nocturnal; it has strengthened its position by having a varied bill of fare. Then it is endowed with a fine brain, alert senses, splendid muscles, and a very vigorous constitution. Therefore it manages to survive over large areas in Europe and North America, though a big price is put on its head. But we have not yet discovered the whole truth. The otter survives in virtue of two other outstanding qualities: it is a rover, and it shows a high degree of maternal care.

Mr. Tregarthen is right in calling the otter "the homeless hunter," "the Bedouin of the wild." It has not merely one well-hidden shelter or "holt"; it has several. It flits by night from one to another, and they may be ten or twelve miles apart. The otter is very often "from home." "It passes from tarn to stream, from river to shore; it swims far out to sea and reaches isolated rocks; it wanders along the cliffs and explores the caves; it crosses the heather-covered hills and even the mountain-passes, sheltering by day among

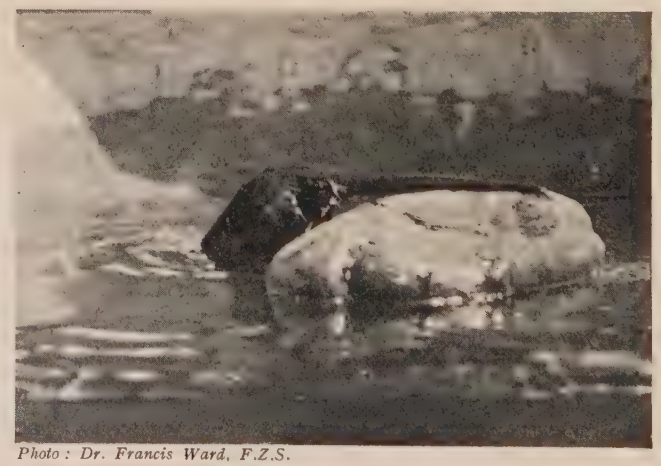


Photo: Dr. Francis Ward, F.Z.S.

THE OTTER BEGINNING A DIVE.

The otter is an expert fisherman, and loses no chance of securing a catch by unnecessary movement or noise. By means of its long flat tail the creature clings to the surface of a rock and lowers its body stealthily into the water.

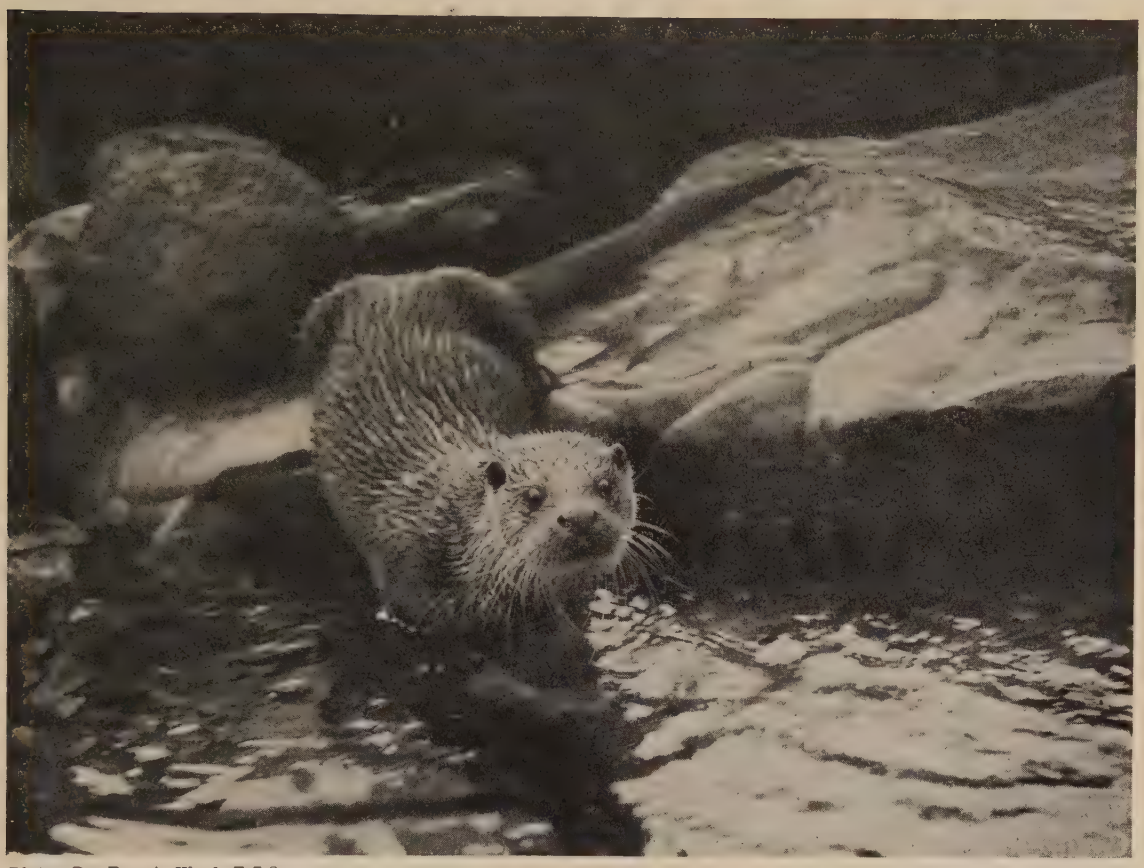


Photo : Dr. Francis Ward, F.Z.S.

FRONT VIEW OF AN OTTER ENTERING THE WATER.

The photograph shows clearly the prominent eyes, short ears and keenly watchful expression ; also the rough appearance of the coat when dry. Once in the water the fur lies close to the body and gives the animal a smooth, sleek appearance.

the thick bracken or in the heart of a cairn ; it neither stores nor hibernates, but is always on the move—a gipsy among carnivores." (Thomson's " Secrets of Animal Life.")

The otter is full of resources, but its severest trial is a hard and prolonged frost, which seals up the loch and drives wild fowl away. The defiant creature can hunt underneath the ice if it finds a hole, and it is said to have a wonderful power of returning to where it entered. But this is a very dangerous game to play, for the hole may freeze and the otter be imprisoned. Those that live near the sea are less likely to die of hunger, and it is a fact that when frost binds the land the otter leaves the hill tarns and the smaller moorland streams, and makes his way down to the estuaries, where the salt water does not freeze, and where, even if the food be coarser and less to its taste it is still plentiful.

§ 5

Family Affairs.

Otters usually have one litter in the year, but two are said to be common in the north of Scotland. The births may occur at any season, but midwinter is a frequent time. A " nest " is made away from the usual shelter or " holt " ; it may be under an overhanging dry bank, or in a cairn, or inside the stump of an old tree, or in the shelter of a cave. The two or three young ones are very helpless at first and grow slowly ; they are blind for over a month. What is most striking is the mother's care. She will hardly leave the cubs except to make hasty rushes to find the food necessary to keep up the supply of milk. She sleeps with one ear open. When the young ones can see, she takes them out for a sun-bath, and grooms them carefully. When they are about two months old, she takes them

to the water, an experience which they do not seem to enjoy at first.

What Mr. Tregarthen has been able to show so well is that the mother otter gives her children the benefit of an elaborate education. She teaches them what certain sounds mean; she punishes disobedience and foolhardiness; she gives them swimming lessons till they are expert, and shows them how to lie quiet beneath the bank of the pool with only their nostrils out of water. She instructs them in the quest for food—how to "guddle" for trout and how to catch frogs. She enforces table manners, for the eel must be eaten from the tail-end and the trout from the head, and the frog must be skinned first. All through the prolonged and detailed education, which is perhaps the chief factor in the otter's success, there is a delicious playfulness. Not only are the young ones frolicsome and playful, unconsciously serving an apprenticeship to the serious business of life, but the mother joins in their games as if she thoroughly enjoyed herself. This occurs year after year, and it may be part of the otter's secret for remaining young. "The playsomest creatures on God's earth," the woodman said.

Photo: Dr. Francis Ward, F.Z.S.

A GOOD CATCH.

The otter is in the main a fish-eater, although its food varies greatly according to circumstances, even mussels and limpets being on its bill of fare. Here it is seen holding a good-sized trout in its powerful jaws.

The Canadian otter, which is a near relative of the Old World species, indulges in a toboggan game. They lie down on a slope of hard snow, bend their fore-limbs under their breast, give a kick with their hind legs, and off they go! Then they climb laboriously up again—they cannot move on land so well as our otters do—and repeat the performance, continuing until they are tired. The same steep bank of snow is used over and over again, until a well-marked "chute" or "slide" is formed. It is a great pity that the delightfully playful Canadian otter is becoming rarer every year, and simply because man is over-greedy. The European species is still fairly plentiful in the British Isles, much more so than is commonly imagined.

Before we leave the roving, playful, resourceful otter, we wish to refer to the rather interesting fact that the young are at first averse to the water. They are ill at ease, and call pitifully for their mother, who does not leave them too long. Sometimes she encourages them by giving them a ride on her back as she swims. This unpreparedness of the young ones for aquatic life is at once intelligible when we remember that they are derived from a terrestrial stock that took to the water as a second string to their bow. In the same way we can understand why the mother otter has to teach her offspring to like fish, for flesh was the food of their ancestors. These are simple instances of the way in which the past lives on in the present.

§ 6

Three Stories of the Stoat.

In one and the same place, the golf links at Balgownie, near Aberdeen, we got three interesting glimpses of the life of the Stoat—a common British carnivore of the Bear tribe. They form a good illustration of the ways of big-brained mammals just because they are not extraordinary—any one can "cap" them.

In front of us we saw what looked like a great brown snake, six feet long, wriggling through the wiry grass called "bents." It made us rub our eyes and crane forward. Then we saw that

A FIRST FISHING LESSON

The mother otter gives her cubs an elaborate education. As part of their training she teaches and encourages them to swim by giving them a ride on her back in the water, and when they have become proficient she trains them in the quest for food. Here we see the cubs being instructed in the art of catching fish

it was a mother stoat with no fewer than seven youngsters in Indian file behind her, the head of one practically touching the tail of another. She was taking them from the bents near the seashore to the rough ground further inland, from their birthplace to their school. As the procession quickly swung across the fairway of the golf-course, across the valley, and up among the gorse on the other side, it looked, we say,

The swimming powers and the agility of the otter make it a formidable enemy of fast-moving salmon and trout. Here one is seen twisting and turning in rapid pursuit of—

like a long brown snake, and every link in the chain was like a snake, so supple and lithesome are the little creatures. We knew what would have happened if we had been foolish enough to run forward; the mother would have turned on us in defence of her children. But we soon lost sight of them in the "rough."

Another day, as we were approaching a putting green, we saw a circle of small birds, including larks and meadow-pipits, quite still on the grass. We wondered why they were so quiet, so we approached very slowly, and then we saw a strange sight. In the middle of the "gallery" of birds there were two young stoats behaving in an extraordinary way. They were jumping into the air and turning somersaults; they were gambolling; they seemed to us to be making "living wheels" of themselves. The little birds were standing as if spellbound, preoccupied with the strange behaviour of the stoats. We should not use the word "fascinated," but there may have been some deep-seated dread beneath what looked like amazed interest. But we had to go on, and at the first movement forwards the stage was empty—birds and stoats had vanished. We know, however, that if we had been able to make ourselves invisible, there would soon have been two birds missing and two stoats well pleased. For it is a device that stoats sometimes employ in catching birds. It is like turning play to a use. The birds are preoccupied—we came quite near them—and their interest is their undoing. Two quick jumps and two birds are instantaneously dead. It is all so quick, that it is sheer nonsense to speak of cruelty. Every creature must die some time.

Another morning, on the same links, as we followed the crooked path of the little white ball, we saw ahead of us a stoat going very slowly. We wondered why it was going at such a sluggish pace, for stoats usually lope along the ground at a great rate. We could not but overtake it, and though we cried "Fore," it did not go any faster. We would not have hurt it for the world, but we had to keep moving, for there were other golfers behind us, and *then we saw*. It was a mother stoat, taking a single young one on its first excursion—a young one of so tender an age that it could not run. Now what did the mother do? She seized her child by the nape

Photos: Dr. Francis Ward, F.Z.S.
a large fish, which it eventually succeeds in seizing by the head.

of the neck, ran forward quickly, laid it in a bunker, and then came to meet us!

Such were three snap-shot observations of a common animal in one and the same place. They might be extended and deepened, readily enough, by anyone who has access to Wild Nature. They were simple observations, yet how "brain-stretching"! How many problems they raise in the enquiring mind. They give us glimpses of *the subtlety of life.*

XII
SOCIAL MAMMALS

§ 1

THERE are different levels among social mammals, as contrasted with "solitaries" like the badger, the otter, the wild cat, and the fox. First there are those that often live together in large numbers, but have no communal life. This is illustrated by a rabbit warren. It is possible that the large company makes it less easy for rabbits to be taken by surprise when feeding and playing at dusk, but, so far as we know, rabbits never act in common, and there is no posting of sentinels. The same may be said of the prairie-dogs of North America. Numerous individuals live together, because they have found a suitable place and because they multiply rapidly; they are just on the verge of being social, but that is all.

Various Levels of Social Life.

Yet it is impossible to draw a hard and fast line. The late Mr. W. H. Hudson tells us in his charming "Naturalist in La Plata" that the Viscachas of the Pampas have a good deal of "conversation" with one another, and that they have games together. They belong to the order of Gnawing Mammals (or Rodents), and they sometimes do much harm to crops in the neighbourhood of their village. In exasperation, the farmers sometimes pile up earth over the mouths of the burrows so as to bury the viscachas alive. But during the night there comes a band of viscachas from the next village, and the rescuers dig out their neighbours! Whenever there is combination the social note is sounded.

To take another example, of which we have more to say in another chapter, the Scandinavian

Photo: New York Zoological Society.

NORTH AMERICAN PRAIRIE DOGS OR MARMOTS.

Although the prairie dogs live together, ten to twelve often occupying the same burrow, it is not because of a desire to unite in food-finding or for protection. A suitable site happens to bring them together, and their prolific breeding leads to a community life bordering on the social. The illustration shows the way these rodents hold their food while eating and how they cut up grass.

Photo : H. J. Shepstone.

NORTH AMERICAN WAPITI.

The so-called "elk" or wapiti (*Cervus canadensis*) is nearly related to the European red deer. It used to be very common on North American plains and foothills, but is now a relatively scarce mountain animal. Most of the survivors are in the Yellowstone Park region. It must not be confused with the moose (Alces).

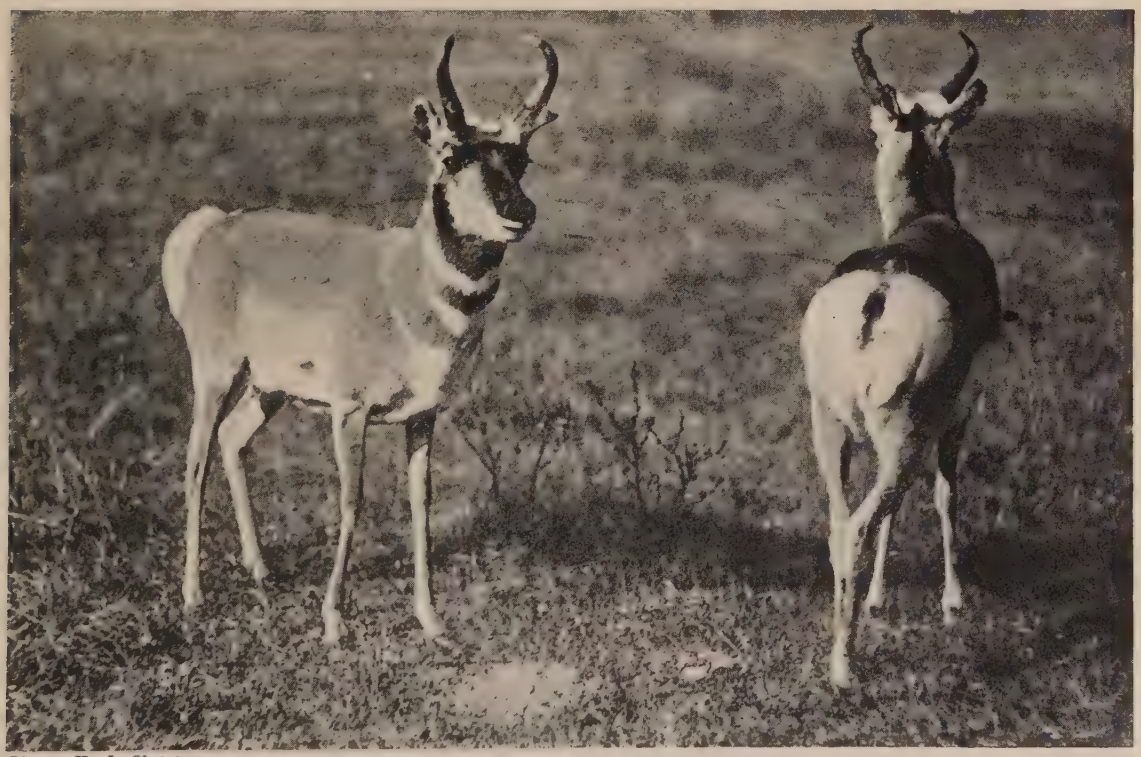


Photo : H. J. Shepstone.

ANTELOPES.

Antelopes are gregarious ruminants. They are almost all either African or Indian, belonging to the family Bovidæ, which also includes cattle and sheep. They are not nearly related to deer.

Photo: Underwood Press Service.

THE GIRAFFE.

Two species of the giraffe have been identified: the Southern or Cape giraffe and the Nubian or Northern species, both of which run in small troops in forest country. They feed almost entirely upon the leaves of the Acacia tree and belong to the ruminants, or cud-chewers being intermediate between the deer family, Cervidæ, and the hollow-horned Bovidæ—oxen, sheep, and antelopes.

lemmings live together in large numbers in suitable places, but they have no communal life. Yet when they are forced by lack of food to go on the march, they combine in a great army, and in this combination there is the beginning of social behaviour.

The second level is that illustrated by herds of deer, antelope, wild cattle, and the like. Here the advance is to be seen in *combined action*. The herd moves as a whole; the members unite their forces against a common enemy. Thus the little shaggy dark brown musk-oxen of the Far North in Canada retire before the pack of wolves till they reach a height or the foot of a cliff, where they form a circle or a semi-circle with the calves in shelter and an array of formidable horns fronting the foe. What the musk-oxen do for defence the wolves do for attack, and there is sound Natural History in what we read in Kipling's "Jungle Books" about the laws of the pack. There is team work, and the pack is able to surround a small flock or to overcome a formidable enemy just because the members play the game and do not work each on his own. In herds there is often a posting of sentinels and the use of danger signals. In many cases, as in reindeer, there is a periodic mass-movement or migration from summer quarters to winter quarters and back again, and this is on a higher level than the occasional trekking of large numbers of rats or lemmings.

The third level among social creatures is well illustrated by the beaver village, which is nearer to the "hive" than to the "herd." For beavers combine in common enterprises, such as building a dam or cutting a canal; and their story is so interesting that we must give it room by itself.

Photo: L.E.A.

NORTH AMERICAN BISON.

Characteristic of the open plains, the American bison, wrongly termed buffalo, differs from the European species, which frequents the forest tracts. Weaker in its hind-quarters than its relative, the American animal possesses a greater strength in neck and shoulders; and this makes it safe from all foes with the exception of man, who hunts it for its skin. But man's greedy hunting has led to the reduction of the bison to a few herds, now carefully protected.

§ 2

The beaver is one of the Gnawing Mammals or Rodents, and has squirrels as its near relatives.

The Story of the Beaver.

It cannot be said to belong to a clever race, and we suspect that most of the admirable things it does are the outcome of inborn instinct, not of lessons which it has intelligently learned.

It used to be a native of Britain, and there are traces of its industry ("beaver meadows") still recognisable in some parts of the country. But it is long since gone from Britain, and in Europe it lingers only in very secluded corners. Even in North America, where it used to be very abundant—for the American beaver is almost the same as the European one—it is becoming more and more restricted. It is being pushed further and further westward. The fact is that its fur is all too dangerously good, and in spite of its shrewdness and social habits, the beaver is not holding its own. Its relationship to squirrels is rather interesting, for both of them have more or less left their original headquarters—the solid earth—and found out new homes. The most thoroughgoing squirrels have become tree-mammals; the beaver has taken to the water.

It is suited for life in the water in having thick, waterproof fur, in having webbed hind feet, and in having a strong, flat, scaly tail, which is used as a rudder in swimming. The old mistake dies hard, that the beaver uses its flat tail to plaster down the clay that forms part of the dam. But that is one of the things the beaver does *not* do. In the summer months beavers often roam about for considerable distances, enjoying abundant food, but the heavy, rounded body and the short legs are not well suited for trotting about on land.

Beavers have many safety-giving qualities, and they would be prosperous still if man had not attached so much value to their thick, silky under-fur. Formerly beaver fur was used in the making of top-hats, but since silk was substituted in this manufacture, the beaver is gradually returning to its old haunts. The animal is protected by law in most States of the American Union, trappers being restricted to so many pelts during the season. Beavers find safety in their powers of swimming and diving, and in their habit of storing twigs and pieces of branch ; there is safety in their nocturnal habits and in having a long bill of fare, for they can eat many different kinds of vegetable food ; but, most of all, there is safety in the way they help one another and in their inborn efficiency.

There is first of all the business of felling trees, which are often up to sixteen inches or so

WEASELS PACK HUNTING.

Working by scent like hounds, they sometimes travel nose to tail in a long line, which at a distance has a curious resemblance to a large snake gliding over the ground. Though sometimes gregarious in their hunting and trekking, weasels are in no sense social. They are much smaller than stoats and have a much shorter tail.

in diameter. With the chisel-edged front teeth the beaver cuts two parallel furrows *across* the grain of the wood, and then wrenches off the part between in a succession of chips. It then makes another parallel line, and gouges off another circle of chips. It goes on doing this till a biconical or hour-glass-like excavation has been made all round the tree, which then falls. A careful observer records a case where a cotton-wood tree nearly thirty inches in diameter was felled so skilfully that it tumbled with its top right into the middle of a small beaver-pond, thus assuring abundance of food for the animals at their very door. But this was probably more through luck than good guidance, for things do not often turn out so well. In many cases the tree falls the wrong way. The tree chosen for cutting is often at a considerable distance from the lodge, so that it does not matter much how it falls. Moreover, beavers seem often to tire of a tree and leave their work half done, it being a common feature in instinctive activity, that if there is a bad interruption, the work is abandoned. It seems that we must give up the story of the beaver-woodmen cutting their tree unequally so that it must fall to the most convenient side, and the other story of the beavers intentionally leaving a tree half cut through, so that the rest of the felling might be done by the next gale! Beavers are wonderful enough without these yarns. The tree they like is one under a foot in diameter, and the meaning of the felling is to bring many sappy branches within easy reach.

Photo: New York Zoological Society.

A BEAVER'S HOUSE OR LODGE.

Though not possessing the intelligence displayed by dogs or monkeys, this rodent has remarkable instincts and achieves very striking results by co-operation. The illustration shows a beaver lodge—a rough structure of sticks and mud, divided into two compartments, the living-room and the store.

Another line of activity is making the pond and its dam. The use of the pond is to have fairly deep water round the lodge, so that the beavers can swim underneath the ice in the winter. The depth of the water secures an open under-water door, and the depth is secured by the dam. This is an entanglement of drift-wood, willow branches, and the like, strengthened by mud and stones, which the beavers carry in their hands pressed against their breast. The branches and twigs are carried in the mouth. Streams of considerable breadth are sometimes dammed, but this is exceptional. It is said that the barrier is built straight across when there is almost no current, but with a convexity directed up-stream when there is a considerable flow. But it is possible that this up-stream curve may be explained mechanically without crediting the builders too generously with wits. It must be remembered, also, that after a flood there is often in a narrow stream a blockage due to

Photo: New York Zoological Society.

A BEAVER CANAL.

The engineering operations of the beaver include making canals, along which they float cut-off pieces of branches. More frequently the animal uses the flooded pathways of the woods for this purpose, only cutting a new canal when nothing else offers. In canal-cutting they work together in large numbers, sometimes excavating for several hundreds of feet.

driftwood, and that this barrier naturally forms where it is most difficult for it to be carried away. Such a natural and temporary dam might well be the beginning of the beavers' artificial and permanent dam. For animals are more likely to adapt than to invent.

There are other interesting points about the beavers' dam, such as the way in which some of the branches may begin to grow into rooted bushes, thus strengthening the construction and hiding it in green in the summer. But the most interesting thing to us is that many beavers may combine in their enterprise, which benefits many lodges, not only one.

Two kinds of houses are made by beavers, and there are many intermediate forms. In rivers like the Colorado, with high banks and a changeable water-level, the beavers make a tunnel well under water, and this leads to a large burrow in the bank. That is all the house there is; but in other cases the beavers make a "lodge." This is a roughly constructed, conical erection of sticks and mud, several feet high, eight to ten feet across the base. The door is usually under water, but there may be two doors, one on the ground, the other in the pool. Part of the interior of the lodge is a living-room and bedroom, the rest is a store of cut twigs and branches laid up for the severe winter.

In some cases great bundles of twigs and branches are stored near the door of the house on the floor of the beaver-pond, being weighted down with stones. If this is all correct, it certainly smacks of intelligence. Another interesting point is that in the autumn extra mud is often pressed on the outside of the hut. When this is frozen hard in winter it forms a comfort-bringing wall, keeping out the terrific cold. But more than that, it is a rampart against the intrusions of hungry wolves and wolverines. It is a pity that fanciful pictures have often been drawn of the beaver's lodge, for it is rough-and-ready architecture at the best, not to be compared for a moment to such masterpieces as the wasps' nest or the white ants' termitary.

Beavers are not only gregarious, they are sociable; they are not only sociable, they are co-operative. This is well illustrated by the dam-making, and equally well by the canal-cutting. Many lodges, built around a big beaver-pond, make a beaver-village; and when a beaver-village is well-established for years and years there must be a gradual reduction in the number of available trees. Those nearest the pond will be used first, but in the course of time little journeys will have to be made, just as the trawling vessels of a fishing-port have gradually to take longer and longer voyages. But the beavers have to carry the cut pieces of branches in their mouth, sticking out on each side, and while this is easy enough when the animals are swimming, it is bound to be tedious when they are making their way through the undergrowth of a wood. No doubt they make paths, but there is something better than a path, namely, a canal. The best of these canals are very remarkable. They may be several hundred feet in length. They may make a short-cut between one bend of a snaky stream and another. They may cut right through an island. If we think of the last case, we see we are face to face with a rather remarkable enterprise. Making a long canal is a task which cannot be accomplished by the individual beaver; it must be tackled co-operatively. More than that, if we understand the situation rightly, as shown in an interesting photograph by the Duke of Argyll, the co-operative work would not have much point until it was completed, with an open waterway right through. This looks like working towards an end—however dimly descried. At the same time we all know that in a low wood, by the side of a river, a pathway may readily become, in times

Photo: New York Zoological Society.

AN EXAMPLE OF BEAVER TREE-FELLING.

The food of the beaver consists of the small sappy branches of trees, and in order to secure these succulent dainties the animals fell trees of an average diameter of twelve inches. The sharp, chisel-edged front teeth make this feasible for a single beaver, but there is greater success when several work together.

Photo : New York Zoological Society.

A BEAVER DAM,

which ensures an accessible under-water door to the lodge, safe from the beaver's natural enemies. These dams are built of driftwood and willow branches strengthened by stones and plastered together with mud.

of heavy rainfall or flood, a sort of natural canal. Perhaps in some such paths, naturally turned into waterways, beavers found a hint that they improved on. For, as we have said, animals are more ready to adapt than to invent.

The beavers live together in pairs, keeping true (monogamous). There is a long youthful period, and the family relations seem to be very pleasant. When the beaver-village gets over-full, there has to be a search for new ground, and some observers say that the flitting is on the part of the grandfathers and grandmothers—the old and the bold—but we cannot vouch for this.

We do not think that the beaver is a *clever* mammal, to be compared, for instance, to the fox, stoat, horse or elephant ; but it has the co-operative temperament, an ability to work with others, which is one of the greatest of gifts. It has had, in the course of ages, wits enough to test promptings and suggestions arising from within, and to hold fast to that which proved good. We do not mean that any beaver ever had any idea of a dam and its advantages. We mean that when there were suggestions in the direction of dam-making—partly from the consequences of river-floods, partly from new departures on the creature's part—the beavers tested these and somehow held on to what proved good.

XIII

THE WAYS OF MAMMALIAN MOTHERS

A LATER chapter is devoted to Parental Care among animals generally, but mothering is so prominent among mammals that we cannot leave it out of our study of their ways. It may be mentioned that the very name mammal refers to the breasts of the mother (*mamma*, a teat).

§ 1

Long ago the natives of Australia reported that they knew of a furred creature—the duck-mole or duck-billed Platypus—that laid eggs. But zoologists knew better; they were sure that no mammal could lay eggs. Yet the natives were right. There are two kinds of Australian mammals which resemble birds and many reptiles in being egg-layers or oviparous. They are the most primitive or old-fashioned of all mammals. The duckmole or Platypus is a close-furred squat animal, rather over a foot in length, with a bill like a duck's, and feet that are webbed as well as clawed. It lives in ponds and slow-flowing reaches of rivers, grubbing in the mud for molluscs and other small fry, collecting a lot in its mouth and chewing them afterwards at

Egg-laying Mammals.

Photo: F. W. Bond.

CALIFORNIAN SEA-LION AND BABY.

In the mating season the sea-lions collect in a herd or what is known as a "rookery," the bulls gathering several females around them and fighting desperately for possession. When the "puppies" are old enough, the work of teaching them to swim is undertaken by the cows. This is no easy task, as the young are not at first inclined to take to the water; the mother accomplishes it by taking them on her back, and throwing them off to swim ashore.

Photo: Herbert G. Ponting, F.R.G.S., reproduced from "The Great White South."

WEDDELL SEAL AND CALF.

A large and clumsy member of the seal family, the Weddell seal is greatly valued for its blubber. It is dark brownish-grey in colour and covered with woolly fur. It is confined to the Antarctic.

its leisure. It has true, hard teeth to begin with, but they do not last for more than a year, after which they are replaced by horny plates, which make good crushing instruments. The duckmole is imperfectly warm-blooded, and one may detect a number of reptilian characters, lurking, as it were, in the recesses of its body. It lays two eggs in the end of its burrow beside the water-pool. The egg has a white membranous shell, and may be over half an inch long, whereas a common size for a mammalian egg-cell or ovum is $\frac{1}{125}$th of an inch. What makes the egg of the duckmole large is the yolk, which is practically absent from the egg-cells of ordinary mammals. To put it shortly, the egg of the duckmole is very like a reptile's egg. When the young one is hatched, it licks a patch on the under surface of its mother's body, where the milk oozes out by numerous openings. Since there is no teat or mamma for the young one to suck, the duckmole is not in the literal sense a "mammal," but it would be very pedantic to refuse it the title.

The Spiny Ant-Eater or Echidna is a terrestrial animal, about a foot in length, powerfully built, with many hairs transformed into strong spines. It can burrow quickly, sinking into the ground so that the last part seen is the ridge of the back. It has a long, slender snout, and out of the toothless mouth comes a slender, glutinous tongue, which is very useful in catching ants. Like the duckmole, the spiny ant-eater is imperfectly warm-blooded, and its temperature may change several degrees in a few minutes. When winter comes the creature falls into a state of hibernation in a confined space.

The egg is like that of the duckmole, but when it is laid the mother takes it in her mouth and places it in a forward opening pocket on the ventral surface, where it undergoes development. The milk-glands open on the side-walls of the pocket, which some zoologists regard as a greatly expanded and hollowed-out teat. It disappears when the breeding season is over. It is interesting to notice that the "milk" of the spiny ant-eater is very different from ordinary milk. It is very rich in proteins or white-of-egg substances; it has little or no sugar; it has no phosphate salts. The young one probably licks the inside of the pocket, where this strange milk exudes.

§ 2

The second rung of the mammalian ladder is occupied by the Marsupials, in most of which the females have an external skin pocket for the shelter and nurture of the young ones. Kangaroos, bandicoots, phalangers, wombats, Tasmanian devils, are all marsupials. They were once widely distributed, for their fossil remains are found even in England, but it seems that they had to give way before other mammals with better brains. So it has come about that apart from the American opossums and the rare selvas from the mountains of Colombia and Ecuador, all the present-day marsupials are Australasian. They have that island continent almost entirely to themselves, as far as higher mammals go, for a geological subsidence very long ago separated Australia from the Asiatic continent before the marsupials had been followed by formidable rivals. In Australia the marsupials have evolved along many different lines, curiously suggestive of several of the orders of higher mammals. There are herbivorous kangaroos and carnivorous thylacines; there is the rodent-like wombat and a remarkable burrower, Notoryctes, superficially like a mole. There are several parachutists, whose webs of skin present a strong resemblance to those of the flying squirrels among rodents.

The Pouched Mammals or Marsupials.

Now, one of the many peculiarities of marsupials is that the young ones are born very ill-developed—as it were, prematurely.

In ordinary mammals, such as sheep and cattle, cats and dogs, rats and rabbits, the unborn young one is very closely bound to its mother's womb, so that it is a sort of partner with its mother for a long time before birth. The organ that binds the unborn young mammal to its mother is called the placenta or after-birth. Except in one case (a bandicoot-rat, called Perameles), there is among marsupials little hint of a true placenta, and the connection between the unborn young one and its mother is less

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A PORCUPINE MOTHER (*Hystrix cristata*) WITH HER YOUNG.

This mother porcupine at the London Zoological Gardens takes her baby for a walk every day. With quills bristling, she is ever on the alert to protect her tiny offspring, which at this stage, like the young of the hedgehog, is not yet covered with quills, having merely a coat of coarse hair. But quills are transformed hairs.

Photo: W. S. Berridge, F.Z.S.

THE URSINE TREE-KANGAROO.

Although, as its name implies, this species of marsupial lives in the trees, it is a clumsy climber. This is outweighed to some extent by its remarkable jumping powers and tenacity of grip. An inhabitant of New Guinea, it feeds on fruit and ferns. In many cases the family keeps more or less to one tree. It has probably become arboreal within comparatively recent times.

thorough. But there is more than that. A pony mare carries her foal before birth eleven months, whereas a large kangaroo, the same size as the pony, brings forth its young one thirty-nine days after its (ante-natal) life began. This new-born kangaroo is blind and naked, and only an inch long. So the mother takes it in her mouth and puts it into her pocket—the external pouch or marsupium in which lie the mammæ or teats. The mother manages somehow to get the young one's mouth over a teat, which then expands a little and gives the baby a grip. But although the mouth is suited for holding on, the young marsupial cannot suck. So the mother has to force the milk into its mouth by the contraction of a special muscle. The milk would be apt to "go down the wrong way" and choke the baby were it not that the opening to the wind-pipe (the glottis, it is called) is shunted forwards into the back opening of the nasal chamber. Thus air gets right down to the lungs, but no milk goes the wrong way. It is very interesting to find a similar adaptation in a whalebone whale, for when it is rushing through the water with its mouth agape, the glottis is pushed forward into the back opening of the nasal chamber (the "posterior nares"). The front nostrils or blowholes ("anterior nares") are at the same time closed by valves, and for these two reasons taken together no water gets down to the whale's lungs.

After a period of development in the pouch, the young marsupial becomes able to stick its head out. It is a quaint sight, when the youngster pops out its head and looks round! By and by it jumps out and begins to fend for itself; but when danger threatens it returns to its safe cradle. The hopping out and in is very extraordinary.

In a minority of marsupials there is no pouch, and then the young ones hang on to their mother's fur, sometimes helped by having their tails twisted round hers. This is also the habit of the young of some of the pouched kinds, they hang on to their mother after they have left the pouch for good. Azara's opossum, a pouchless marsupial about the size of a cat, is said to climb trees very effectively while carrying eleven rat-sized young ones on her back. And they do not even intertwine tails. We see, then, that while these marsupials are behind ordinary mammals in the connection between young ones and mother *before* birth, they have an unusually close and prolonged partnership *after* birth. It is hardly necessary to say that the pouch or marsupium is confined to the females.

There is a very dainty marsupial in Queensland and New South Wales, called the Pigmy Aeroplaner (*Acrobates pygmæus*), which is not so big as a mouse. It has a web of skin drawn out from the sides of the body between the fore and hind limbs, and this is used in gliding from branch to branch. The pigmy mother has only four teats in her pouch or marsupium, but there are far more young ones. This leads to a serious difficulty. When the young one is born it is almost incredibly small—it is not longer than the breadth of our little finger nail. It crawls up the body of the mother, hanging on to the hair, and if it reaches the pouch in time it is safe. But as the pouch will not accommodate more than

four, only the first four can survive. The others die in a very short time—a few minutes!

It seems to be a common thing among small marsupials that more are born than can survive; a number are only born to die. One might think that the young ones could change about inside the pouch, for we see big animals with more offspring than there are teats for. Thus the wart-hog has six to eight in a litter, and only four teats. But the difficulty with the small marsupials is that when one has got its mouth over a teat, it does not let go for weeks. In some cases at least, it *cannot* let go until it is able to leave the pouch.

What can one say of a case like that of the Pigmy Aeroplaner, where one has to face what looks like a serious mistake? There are two things to be said: first, that all arrangements among animals are not equally perfect and that some adaptations are still in process of being adjusted; and, second, that when it is difficult for the very fragile and very partially developed young one to get into the pouch, a margin must be left for safety. Those pigmies have survived that have a wide enough margin as regards number of offspring.

§ 3

Maternal Care among Higher Mammals.

In all the ordinary mammals that we are familiar with—monkeys and apes, carnivores like the lion, insectivores like the hedgehog, rodents like the hare, hoofed animals like horses and cattle, and more divergent forms like sloths and ant-eaters, cetaceans, sea-cows, and bats—there is a complex organ, already named as the placenta, binding the unborn young one to the womb of its mother. The vital connection is so closely knit that we must use some word like partnership. For while no solid particles can pass from the mother to the unborn offspring, the dissolved food in the blood of the mother must filter through into the blood-vessels of her young one; and there must also be diffusion the other way. The mother contributes soluble food, oxygen, and those invaluable chemical messengers called hormones. The offspring

Photo: F. W. Bond.

RED KANGAROO AND YOUNG.

When young kangaroos are born they are very immature and for many days are almost helpless. But the mother has, like most other marsupials, an external pouch in which to carry the youngster, and even when the baby leaves the pouch and is well able to fend for itself, it will return to its cradle at the slightest threat of approaching danger.

returns nitrogenous waste, carbonic acid gas, and also hormones. For they say that the unborn offspring does in some measure reward the mother for her sacrifice by contributing chemical messengers, which seem to help her to make the most of her own food.

We have used the word sacrifice in connection with these mammalian mothers, for we must think of a case like the elephant, where the mother carries the young one before birth for twenty-two months, and where she contributes enough of fluid food to build up a young elephant which is already about a yard high when it is born. The building materials for such a large baby must mean a large sacrifice of the mother's food, but the sacrifice is, of course, quite unconsciously made.

There are great differences in the length of the sleep before birth, and the general statement may be made that the longer it lasts the more developed will be the brain and the body architecture of the young one when it is born. The big-brained, clever mammals usually require a long sleep before birth. Thus a monkey's young one may be carried for seven months before birth, whereas young rats are carried for only three weeks or so. But there is another thing to be thought of in this connection. When the mother has a well-hidden den or nest, or when she carries the baby or the babies about after birth, it is quite safe for the young ones to be born very helpless, and they are often blind and naked. Everyone knows the helplessness of young kittens and young rabbits. There are advantages in the prolongation of this period of helpless infancy, so very marked in mankind, for it secures a long sheltered time during which the body and brain can grow in gradually expanding surroundings; and it must also tighten the bonds of affection between parents and offspring.

Photo: Underwood Press Service.

THE GREAT GREY KANGAROO.

The figure shows a famous kangaroo in the Melbourne Zoological Gardens. Its wild relatives in Australia are very formidable, both to men and dogs, when at bay. They seize their enemy in their arms and use the powerful claws of their feet with deadly effect.

There are other conditions of life, however, where it is necessary that the newly born young one should be on the spot almost at once, because the situation is full of danger. So just as there are some newly hatched birds, such as plovers, which are able to run about the very first day, so there are precocious young mammals, such as foals and lambs, which can move about almost at once. In natural conditions, such as those of wild asses on the steppes, it is necessary that the foal should be able to follow its mother in a very short time. We are not surprised, therefore, that the mare should carry its young one before birth for eleven months. It is interesting to notice that the foal takes only a short drink of milk, for it is a mover-on; whereas the calf, which is hidden by its mother in the thicket, takes a large drink all at once.

Similarly, as a young whale is born in the open sea, we can understand why it

Photo: James's Press Agency.

THE HARVEST MOUSE AND ITS NEST.

Next to the Lesser Shrew, this is the smallest of British mammals. It builds a globular nest, suspended between two or three corn-stalks. After the young are born the mother emerges and carefully closes up the opening to the nest. How she succeeds in feeding her babies is still uncertain. Perhaps she makes a special opening for the purpose, closing it again after she has finished. Or it may be that she presses her soft body against the nest from the outside, near each little mouse in turn, moving all round the nest until the task of feeding her young ones, sometimes as many as ten in number, is completed.

is a much more wide-awake creature than the young seal, which is born on the shore, and would drown if it fell into the water too soon. We are not surprised that the mother-whale should carry its young one for a whole year before it is born, whereas a rabbit, with its young ones born in a safe burrow, carries its young ones only a month before birth.

§4

Care After Birth.

In some of the tribes of Central Africa the mother carries the young child on her back or on her side all the day long. As she works in the field, or milks the cows, or goes about the hut, she has the baby always with her, and the child often clutches hard. Similarly, the mother monkey often carries her child from tree to tree, and the father sometimes gives her a rest by taking his turn. We have spoken already of certain marsupials that sometimes climb or even swoop with their babies on their back or in their pouch, but still more daring is the mother-bat, who flies in mid-air with her offspring clutching her breast with its thumbs, and closing its tiny front teeth on the curiously roughened hair. It is hardly necessary to say that a bat has very rarely more than one offspring at a time. One is enough for a flying mother to carry about, and the small number also indicates plainly that bats are very safe in the struggle for existence.

The hippopotamus-mother sometimes carries her youngster astride her neck in the water, and the same is true on land of the South American Capybara, the largest of living rodents, that stands as high as a sheep. The mother sea-cow or dugong is believed to have given origin to some of the mermaid stories, for she uses her flipper to press her baby to her breast.

There is a curious performance in the case of the great elephant-seal. The young one is born on shore, but after it has had a good meal it shuffles down to the sea, for which it is not yet ready. The mother accompanies it and rescues it from drowning, driving it ashore. But this plunge after the meal seems to be essential to the young one's health.

Among deer it is not difficult to find cases where the young one is unable to move about for several days after birth. In these cases the mother hides her offspring in a thicket, and this is half-way to a nest! But true nests, so characteristic of birds, are not unknown among mammals. The tiny harvest-mouse weaves the leaves together and hangs its hammock from the swaying wheat. Even the rabbit pulls her fur off to make a bed for the young ones at the far end of the burrow. Amongst the branches of the tree, or where the main stem forks, the squirrel makes a large nest of moss and twigs, and there the young are nurtured. The nest is often conspicuous, for the squirrel has few enemies. It might be said that the squirrel's nest differs from a bird's nest since the mother squirrel does not *brood*, but that is a distinction without much difference, since there are long, quiet times of suckling the young. Should danger be very pressing, in the shape of a woodman, let us say, the mother-squirrel may shift her young, carrying one at a time in her mouth.

Many are the instances of the furious mother-mammal, who will defend her young ones at the risk of her own life, and everyone has heard of the rage of the she-bear bereft of her whelps. The finest of all expressions of maternal care, we

Photo: W. S. Berridge, F.Z.S.

THE ECHIDNA OR PORCUPINE ANTEATER.

This animal represents the lowest order of mammals, sharing with the duck-billed platypus the peculiarity of laying eggs instead of bringing forth living young ones. It has a long, worm-like tongue, which is well adapted for catching the ants on which it feeds.

Photo : Underwood Press Service.

MARE AND FOAL.

The mare's loving anxiety for her foal's safety often makes her dangerous. Among mammals there are few instances of more intense maternal care.

think, are seen when the mother, as we noticed in the case of the otter, gives her offspring a patient and painstaking education in all the ways of woodcraft in which they should go.

§5

The Virginian Opossum.

The pouched mammals or marsupials were in past ages widespread in America and in Europe, but nowadays they are, with the exception of the American opossums and the little-known mouse-like selvas of Ecuador and Colombia, restricted to Australasia. The selvas are primitive creatures, the sole survivors of a family which once had many representatives. They might be metaphorically called "living fossils." Had they not learned to live in a very quiet way in secluded parts, they would long since have suffered the fate of most of their kindred. For, with the exception of the arboreal opossums, marsupials seem to have gone to the wall before the better-endowed higher mammals, and only those were saved which had established themselves in Australia before that great continent became an island, and before the higher mammals had been able to reach that region. Australia was once connected with the Asiatic continent by a great land-bridge extending across the Java Sea. The marsupials were saved by insulation, and in the absence of formidable rivals they flourished in Australia and evolved many different types—some herbivorous, some carnivorous, some like rodents, some like insect-eaters.

There are over a score of different kinds of opossums in South America, but the only North American representative is the Virginian species that extends from New York to Florida and holds its own in spite of terrible persecution. We read that in 1911 a London house dealt with over a million opossum skins, which are much sought after for the sake of the woolly under-fur. We may wonder how the opossum manages to survive, especially since its flesh is palatable, and forms a favourite dish all through the southern States.

Photo: F. W. Bond.

THE TASMANIAN DEVIL (*Dasyurus ursinus*).

About the size of an English badger, this savage, pouched animal is rapidly becoming scarce. Nocturnal in its habits, it preys persistently on poultry and lambs. It is a marsupial that has evolved in adaptation to carnivorous habits, but its resemblance to a true carnivore is quite superficial.

The Virginian opossum is a small animal, with a head-and-body length of fifteen inches, and a naked white tail about a foot long. This tail is of great importance in everyday life, for it is as prehensile as a monkey's, and is of great value in climbing. Getting off the ground always means some security, but the opossum has not given up its terrestrial footing. It can burrow as well as climb, and it sometimes gets so far under the base of a tree that it cannot be dug out. Another quality of great value in the struggle for existence is the wide range of the opossum's appetite. It can make a meal of fruits or roots, of nuts and green corn, of grubs and eggs, of young birds and young mammals. It thrives so well on its varied fare that it lays up underneath its skin a store of fat, which keeps it going in the depth of winter.

The familiar phrase, "playing 'possum," refers to the opossum's device of "feigning death" when in a tight corner. Engrained in many animals is the tendency to become motionless when there is a sudden change in the external conditions of life. They pass into a cataleptic state of rigidity, and this is sometimes life-saving, for there are many predatory animals that will not seize anything that is not moving. Somewhat higher in the scale, probably, is the tendency that some animals have to pass into a state of "animal hypnosis." At a critical juncture, when they are rudely shaken, or lifted off their feet, or turned upside down, they become rigid and unresponsive. This may be illustrated from the crab on the shore to the frog in the marsh, and from snakes to poultry. It is not deliberate at all, but an involuntary reaction engrained in the creature's constitution. It is often life-saving. Somewhat higher still is the opossum's feint, which is also illustrated by a number of much cleverer animals, such as Reynard the Fox. It is not a device that the individual thinks out, but a racial tendency to "lie low and say nothing." There may be something of a faint as well as a feint in it; but there is much to suggest that the self-controlled creature is on the spot for at least a large part of the time—

it is so quick to seize an opportunity when its captor has released his grip. Then it pulls itself together and is off !

Although the Virginian opossum is a common animal, it is elusive, and very few naturalists have seen much of its family affairs. But a careful study recently made by Mr. Carl Hartman of the University of Texas has dispelled many obscurities. The breeding season begins in Texas in January, and by the middle of February most of the females have young ones in the pouch, which is an external depression of skin surrounding the milk glands. As these young ones in the pocket were born some time before, it follows that the period of development before birth must be very short. It lasts, in fact, only about eleven days, and we cannot be surprised that the new-born opossums are peculiarly helpless. They are born *half-finished*, a little over an inch long !

It has for long been a debated point how the young ones got into the external pocket, and several ridiculous ideas on the subject are widespread. A common view, which is not ridiculous, is that the mother takes her new-born offspring—one after another—in her mouth, and puts them into the pocket, fixing them on to the teats. But that is not what Mr. Hartman saw in the Virginian opossum. A young one is born and the mother licks it dry. The baby then proceeds to climb hand over hand into the pouch, where it fixes its mouth on a teat. It certainly reaches its second cradle without the assistance of the mother.

For two months the young opossums enjoy the food and shelter which the pouch affords. For thirty days after that they move freely about on their mother's body, clinging to her hair, and occasionally twisting their tails around hers. When they are startled or hungry they return to the pouch. Eventually they are weaned, and the mother proceeds after a while to have

Photo : James's Press Agency.

A WILD SOW (*Sus scrofa*) WITH YOUNG.

The young of wild swine are prettily marked with white stripes along the back and sides, but these markings disappear rapidly as the creatures grow older, and develop black, bristly hair. Usually there are from six to eight young ones in a litter and two litters in a year.

Photo: W. S. Berridge, F.Z.S.

THE VIRGINIAN OPOSSUM.

Common in America and living a nocturnal life among the trees, this species is much giving to shamming death, a habit that often saves it from its enemies. From this characteristic has been derived the common phrase, "playing 'possum."

another family, for there are in most cases two families in the year. There are usually thirteen teats in the pocket, but it is very unusual to find them all occupied. Seven to eleven is a common size for a family, but in rare cases there are over thirteen, and then some must die of starvation!

We are now in a better position to understand how the much persecuted opossum holds its own. To the other reasons already given there must be added this supreme one, that the mother opossum is generously maternal, not only in having two large families in the year, but in taking very good care of her children till the apron strings are broken.

Survey.

Looking backwards, but keeping to mammals, we see that the simplest way of providing for the offspring is to have large eggs, that is to say, eggs with a big legacy of nutritive yolk. This method, which is characteristic of birds and reptiles, is seen in the primitive egg-laying or oviparous mammals, the duckmole (Ornithorhynchus), the Porcupine Anteater (Echidna) and another Spiny Anteater which often gets a special name (Pröechidna or Tachyglossus). All three, as we have noticed already, are Australasian. The duckmole or platypus usually lays two eggs, approaching two-thirds of an inch in length, and provided with a tough shell. In a recess of the burrow the mother lies on or round the laid eggs, whereas the Spiny Anteater puts its single egg into an external pocket. The early development of the egg is like that of a reptile's (or bird's) egg, with what is called partial discoidal segmentation of the living matter. The developing embryo lives on the yolk which it gradually absorbs; and it breathes, like an unhatched chick or crocodile, by means of a membranous sac (the allantois) rich in blood-vessels, which is spread out within the porous egg-shell. Oxygen diffuses in, carbon-dioxide diffuses out. When the time of hatching comes, the young creature breaks the egg-shell,

Photo: W. S. Berridge, F.Z.S.

AZARA'S OPOSSUM (*Didelphys azaræ*).

A South American species, Azara's opossum is smaller than its Virginian relative, but has a much longer tail.

Photo: F. W. Bond.

MOTHER OPOSSUM AND YOUNG.

Opossums are the only marsupials found in North America. The Mexican opossum (*Didelphys dorsigerus*), the subject of this photograph, carries her young on her back, after they have passed the pouch stage. With their tails curled round hers, she jumps from branch to branch with her precious burden, helped by her long tail to avoid disaster.

Photo: F. W. Bond.

THE PIGMY AEROPLANER (*Acrobates pygmæus*).

This member of the "Flying Phalanger" family is the smallest of marsupials being hardly as big as a mouse. It is a native of Australia, and is able to parachute from tree to tree.

just as a chick does. It is helped by a conical projection on its snout and a so-called "egg-tooth" just behind the middle of the upper lip. What a strange young mammal it is, with ancestral reptilian characters still clinging to it, as it were! It is blind and naked, about two-thirds of an inch long in the duckmole, about half an inch long in the Spiny Anteater. It soon begins to lick the milk, and on the strength of this it grows.

Now, if we compare this state of affairs with what happens when a snake buries its eggs in the warm sand and leaves them to their fate, we see that there are two steps of advance. There is the beginning of brooding and there is nurture after birth. It must be noted, however, that brooding is also seen in some reptiles, and that it reaches its climax not in mammals, but in birds.

On the second level of mammalian evolution, that of the pouched mammals or marsupials, the eggs are practically yolkless, but there is an ante-natal union between the unborn young ones and the mother. In most cases, this is a rather rough-and-ready union—by means of the yolkless yolk-sac, the blood-vessels of which come into very intimate association with those of the mother, so that diffusion of fluid food and of gases can take place from the one to the other. In one case, however, the bandicoot called Perameles, there is a more finished ante-natal linkage by means of a placenta comparable to that of the ordinary mammals. But in all marsupials the young are born very prematurely and peculiarly helpless—unable even to suck. We have seen how this imperfection is compensated for, in most cases, by a continuation of the development within the maternal pouch.

In ordinary mammals, the minute yolkless eggs develop within the womb of the mother, and the embryos are nourished, after some preliminary makeshifts, by means of a complicated placenta which establishes a partnership between the mother and the unborn young. Thus the newly-born young ones are often highly developed at birth. But even then the mother's care is only beginning! For there is suckling and protection, and often some education. We see why mammals should be called mammals!

After the painting by Philip Rickman.

THE KINGFISHER

Waiting and watching on its perch.

XIV

THE WAYS OF BIRDS

THE ways of birds are of peculiar interest because of their mingling of genuine intelligence with well-established instincts; and there must be added a third kind of behaviour, namely, individually acquired habits. For many birds are very quick to learn new ways.

§ 1

Senses of Birds.

There are two widely open gateways of knowledge among birds: the sense of sight and the sense of hearing. Many of us have admired the quickness and certainty with which gulls will pick up pieces of biscuit from the foam in the wake of a steamer. Not less striking is the keen way in which a hawk scrutinises a hillside in search of young birds and mammals. From a great height it detects a victim, and descends as a bolt from the blue. It is by sight, not by smell, that the vultures gather to the carcass. One vulture sees the mammal stagger and fall, and descends on it; a second, in the next aerial "preserve," follows the first, and a third the second, so the news spreads through the sky. Longfellow uses this picture in illustrating the way in which misfortunes often follow one another:—

Photo: James's Press Agency.

THE THRUSH'S ANVIL.

The thrush enjoys the wood-snail (*Helix nemoralis*) and other snails. To get at the succulent animal it seizes the shell and knocks it against a stone until it breaks. The stone, sometimes to be found in a wood, is called the thrush's anvil. It has been shown that an isolated young thrush gradually learns how to break the shells.

THE MOORHEN AND ITS NEST.

The moorhen, really mere-hen (*Gallinula chloropus*), makes a substantial nest of interwoven flags, reeds, rushes and grass, hiding it cleverly under the overhanging bank of the pond or river, where it is safe from foxes and other prowling enemies.

The hen sits close on a clutch of six to ten eggs, which are pale brown, richly mottled with brownish red. The period of incubation is three weeks, and very often two broods are produced in one summer.

The male bird seen setting off in search of food. In order not to betray the position of the nest he begins his journey close under the bank, and steals away unseen until at some distance from the home.

"Never stoops the soaring vulture on his
quarry in the desert,
On the sick and wounded bison, but
another vulture watching
From his high aerial look-out, sees the
downward plunge and follows,
And a third pursues the second, coming
from the invisible ether,
First a speck and then a vulture, till the air
is dark with pinions. . . .
So disasters come not singly."

A good second to the sense of sight in birds is their sense of hearing. The breaking of a twig is enough to send the bird off at full speed, or to make it utter the danger-signal. Everyone knows how the quick-eared geese saved the Capitol, detecting something unusual in the sounds of the night. The excellence of the song in many birds must surely imply a very fine sense of hearing.

To those young birds that are hatched at a very advanced stage, able to run about almost at once, as we see, for instance, in chickens, partridges, lapwings, and redshanks, the quick ear means much. They have an instinctive or inborn appreciation of a particular warning cry which their parents utter, and whenever they hear it they crouch and lie motionless. Thus in the case of partridges, the parents utter a peculiar cluck-clucking note, and the young birds squat flat and remain absolutely still. They will do this when two or three hours old; yet if they have been reared by a foster-mother hen they do not pay any attention to what she says, no matter how much anxiety she puts into her call. This shows how discriminating the sense of hearing may be, as we know it is in clever dogs that can distinguish their master's motor-horn a long way off, and never confuse it with any stranger's unless of the same type. We shall understand "the ways of animals" better if we linger over the partridges for a moment. The young partridges are unfailingly obedient to their parents' call, yet we cannot suppose that they have at first any understanding of what they are doing when they lie motionless. Their nervous and muscular systems are adjusted from their beginning (by "heredity," as we say), to answer back to one particular sound. We must not think of them as "wise" or "clever"; that is not the right way of looking at it. They

have a ready-made equipment that works infallibly without any "learning." That is the miracle and mystery of instinct.

As to the other senses, birds are not well equipped. Touch cannot be very keen in a creature that is covered almost all over with feathers, which cease to be living when full-grown. But there is sometimes acute sensitiveness about the bill in those birds that feel their food before or without seeing it. Thus the woodcock probes for earthworms in the moist soil of the wood, and the tip of its bill has a fine equipment of nerve-endings. The same is true of the snipe. These birds feel food which they do not see.

Taste is not greatly developed in birds, for they are much given to bolting their food and hurrying on. It is known, however, that chickens soon learn to avoid unpalatable caterpillars, and hungry ducklings will, after one trial, refuse little foreign frogs with poisonous skins.

Little is known of the sense of smell in birds; indeed, it does not seem to have been proved in more than a dozen cases, including blackbird, magpie, and some nocturnal hunters. Of the other senses—of temperature and pressure and balance—little is known. Some naturalists have thought that migrating birds must have "a magnetic sense"; they find their way with such mysterious success. But all attempts to prove this magnetic sense have failed. We know that migratory birds are able to return to their northern birthplace after wintering in the tropics, but we have not discovered their *method*, and not much is gained by speaking of "a sense of direction." To sum up: in the life of birds the senses of sight and hearing count for most.

§ 2

Inborn Aptitudes.

If a boy could ride a bicycle right away the first time he tried, that would be an inborn or instinctive aptitude. Of this kind of gift man shows little, but birds show much. A young coot swims at once when it is tumbled into the water, and this is true of most water-birds. Sometimes they can swim very well, and yet do not seem naturally keen for

The male is most attentive. Here he is seen bringing some of his catch to his sitting mate. The food consists of water insects and their larvæ, as well as the seeds of water plants.

By and by the hen may be seen feeding her first hatched chick. They are charming little creatures, with bright red legs and bills, and, like young chickens, able to fend for themselves from the first.

Finally there is some training of the young birds, but the power of swimming and diving is inborn. The principal enemy of young moorhens is the hungry pike, and to its great appetite they frequently fall victim.

the water. This is noticeable in the water-ouzel or dipper, a bird allied to the wrens, that has taken to the water as a second string. The young bird seems to need a push or a tumble to awaken the instinct. In some cliff-birds, like guillemots and razor-bills, where the birthplace may be a ledge two or three hundred feet above the sea, the parents have to coax or even force the young bird to take the first plunge. Sometimes they help the young bird down. There may be actual instruction in some cases. Thus the mother great crested grebe takes her young ones on her back for a sail, and then, sinking beneath the water, leaves them gently afloat.

§ 3

Instinct and Learning.

The great difference between the behaviour of a bird and the behaviour of a bee, is that the bird has fewer ready-made (or instinctive) gifts and much greater power of learning. We have mentioned the inborn ability to swim, and the same is generally true of flying and diving, pecking and scratching, crouching and lying low. But we soon come to an end of the list, and find the young bird *learning*. Thus Professor Lloyd Morgan observed that his chicks, hatched out in the laboratory away from any bird, paid no attention to their own mother's cluck when she was brought outside the door. Later on, when they were thirsty, and willing to drink from a moistened finger-tip, they did not know what water was for, even when they walked through a saucerful. Only when they happened to peck their toes when standing in the dish, did they appreciate water as the thing they wanted. Only then did they raise their bills up to the sky in the familiar fashion. Later on these unprejudiced youngsters stuffed their crops with red worsted, as if they mistook the pieces for worms. Evidently they were missing their mother's teaching! But the point is that although they made mistakes they did not continue making them. Not more than once or twice did they try the red worsted or the unpalatable caterpillar. They learned with prodigious rapidity.

§ 4

Professor Lloyd Morgan reared two moorhens (or waterhens) away from their kindred, and

Photo: Underwood Press Service.

THE VULTURE.

Vultures form a family of Old World birds of prey, marked by a more or less naked neck and a strong hooked bill. They show great "sailing" power, describing magnificent spirals at a great height, with long intervals between the wing-strokes. It is by sight that they gather to the carcass, the descent of one giving a hint to others.

Photo: G. C. S. Ingram, M.B.O.U.

LESSER TERN ADJUSTING ITS EGGS.

The lesser or little tern (*Sterna minuta*) lays two or three stone-coloured eggs in a scoop among sand and gravel, sometimes with a pavement of pebbles, occasionally with a little grass. The eggs are very difficult to detect among the stones on the beach.

watched them almost from hour to hour. They swam right away, "as to the manner born"—in other words by instinct; but they would not dive, either in a large bath or in a stream, and, of course, diving is somewhat different from swimming. One of these moorhens, when about nine weeks old, was swimming one day in a pool at the bend of a stream in Yorkshire, when a puppy came barking down the bank and made an awkward feint towards the young bird. "In a moment the moorhen dived, disappearing from view and soon partially reappeared, its head just peeping above the water beneath the overhanging bank." This was the first time the bird had dived, and yet its performance was quite perfect. It had no doubt profited by about two months' experience in swimming, but nothing had previously awakened the diving instinct. When the young bird suddenly saw and heard the dog, the trigger was pulled; it was excited, and it did, we think, to some extent appreciate an alarming situation. Intelligence and instinct joined hands, and the young moorhen dived.

Intelligence mingled with Instinct.

In the quiet of the wood one sometimes hears the song-thrush breaking snail shells on its stone anvil, and one sometimes finds the tell-tale evidences of its appetite—a large number of broken shells, just like the heaps that students of prehistoric man call "kitchen-middens." This interesting habit of the thrush, which comes so near using a tool, is it an inborn gift or has it to be learned? The answer is given by Miss Frances Pitt in her "Wild Creatures of Garden and Hedgerow." To a young thrush which she had brought up by hand, she offered some wood-snails (*Helix nemoralis*), but he took no interest in them until one put out its head and began to move about. The bird then pecked at its horns, but seemed amazed when the snail retreated within shelter of its shell. This happened over and over again, the bird's inquisitiveness increasing day by day. The thrush often picked a shell up by the lip and let it fall again, but no real progress was made until the sixth day, when the bird seized a snail and beat it on the ground, somewhat in the same way as thrushes do with a big earthworm. At

The Thrush's Anvil.

last, on the same day, he picked up a snail and hit the shell repeatedly against a stone. He tried one snail's shell after another, just as if he had made up his mind, and after fifteen minutes' hard work he managed to break one. He had cracked his first shell, and after that all was easy. A tendency to beat things may be inborn in the thrush, but in this case he learned intelligently how to solve a difficult problem.

As is common among backboned animals, birds often show quickness in forming a linkage between some sight or sound and an appropriate action. A moorhen chick for whose delectation Professor Lloyd Morgan used to dig earthworms, soon learned to run to him from some distance whenever he took the spade in hand. We do not need to suppose that the bird said to itself "He has got hold of the instrument that discovers worms for me," but there was an association formed in the bird's mind between the picture of the spade and a pleasant experience.

It is this power of association that is taken advantage of in training birds to perform little tricks. Sparrows, cow-birds, and even chicks will learn to distinguish clear-cut marks on cards, and will pick out a particular card on getting a certain signal. Speaking of his Indian weaver bird (*Ploceus baya*), Mr. C. H. Donald writes: "His extraordinary intelligence and his natural love for inspecting everything he sees and picking it up in his beak have been taken advantage of to teach him tricks. He is a very apt pupil, and if carefully and kindly taught will, within a week, select a particular number out of many cards and bring it to his master. He will catch a two-anna piece which has been thrown into a well before it reaches the water and bring it back. Some of his tricks seem absolutely incredible, and yet one and all may be taught in a couple of days each. The first and most important step in his training is to teach him that an open hand means food, and that a closed fist does not. Everything hinges on his first mastery of this secret, and the rest is simple." The weaver bird has a fine brain, it is a clever manipulator in nest-making, it is quick in its movements, and its tricks depend on these endowments, along with a rapid power of linking things together in its mind.

Naturalists often test animals with a maze or labyrinth, like the one at Hampton Court, but simpler. It is interesting to know that this examination has been passed by the house-sparrow, the cow-bird, and the pigeon. In the case of a full-grown pigeon the solution remained in the bird's possession for a month at least.

Photo: E. J. Manly.

INDIAN WEAVER BIRD.

The weaver birds make neatly woven retort-shaped hanging nests of woven grass. The Indian *Ploceus baya* balances its nest with lumps of clay. The weaver birds are of lively intelligence and very quick to learn, as is well shown by the tricks of *Ploceus baya*, often exhibited on the streets of Indian towns.

§ 5

Everyday Life.

When we watch birds collecting food and dealing with it, or building a nest and rearing their young ones, what is our general picture of their behaviour? In many cases they have, as we have seen, inborn gifts or promptings or abilities, which we sum up in the word *instinctive*. We use this adjective to cover not only chains of actions, such as those involved in nest-building, but also simpler pieces of behaviour, such as catching the food in a particular way. But the birds add to this the clevernesses they learn by making trials and mistakes, and linking things together in their mind. A smooth, juicy caterpillar appears on the scene, and the picture gives the signal "Full steam ahead." A hairy

Photo: S. Crook.

YOUNG SWIFT, SEVEN DAYS OLD, SHOWING ITS CLINGING POWER.

The four clawed toes, all pointing forwards, take a firm grip of any rough surface, such as this branch. This is an inborn capacity, a "reflex action," like sucking or sneezing.

caterpillar appears on the scene, and, unless the bird is a cuckoo, the chances are many that the signal will be "Reverse engines." This is the outcome of individual experience. But to these associations there are added the results of parental instruction and of imitation. Finally, there is sometimes genuine intelligence, when the bird puts two and two together and makes a simple judgment.

Many of the ways of birds are minglings of several different kinds of behaviour, and we have tried to show how it is possible to distinguish several different kinds. Let us take an example. Some young woodpeckers show remarkable dexterity in opening fir cones to get at the seeds. This one might at first sight call instinctive, like the coot's readiness to swim the first time it tries. Or one might put it down to sheer intelligence, to an understanding of the problem. There would be nothing unreasonable in either of these ways of looking at the young woodpecker's behaviour. Yet neither of the suggestions is quite right. For we find that the parent birds bring their young ones first the seeds themselves, then partly opened cones, and finally cones that have not been touched. There is a gradual process of teaching and learning.

§ 6

Social Birds.

It is generally agreed that the cleverest birds are rooks and parrots, which are well-known to be social and talkative. Both have very good brains, and this may have led to their social habits. On the other hand, the relatives of rooks, such as carrion-crows and ravens, have also very fine brains, and have remained solitary. All the European relatives of the rook are solitary except the jackdaws. Perhaps there is some difference in mood between rooks and crows.

Another way of looking at it is this: living together and talking a good deal may have favoured progress in the direction of nimbler wits; for these things often work round in circles, and it is a great law of progress in the world of life that to him that hath, more shall be given. Let us think of rooks for a little.

The Story of the Rooks

It is in February that the story of the rooks begins, for that is the time of courting. The cock-bird struts and bows before the hen, and spreads out his wings and tail; and, as Gilbert White noticed, "rooks, in the breeding season, attempt sometimes, in the gaiety of their hearts, to sing,

Photo : Albert Henry Willford.

A ROOKERY.

The trees chosen for the rookery are often near houses. They are usually deserted after the nestlings have flown; and the roosting place, often at some distance, may include the rooks from several rookeries.

but with no great success." The strutting and bowing and "singing" may occur at other seasons, when the rooks are well pleased with the world, but it is most marked during the courtship. An interesting little ceremony is sometimes seen. The male bird brings his desired mate a little present—some tit-bit or other—which she accepts with thanks if she likes him. Two rooks seem to remain together for life, but there is a courting every year.

Early in March, while it is still very cold, the rooks begin to prepare a nest. Sometimes they use an old one over again, after a thorough spring-cleaning. There is a good deal of disputing over the twigs, and up to a certain stage they steal from one another if they can. But one rook usually mounts guard while the other breaks the twigs from the leafless trees. After a while they exchange duties. To the pliable twigs they add some earth and clay, and the inside of the nest is made comfortable with grass and leaves, hair and wool. There are often a dozen nests on one tree, and as many as thirty have been counted. If a branch breaks off, or if there is even a hint of such an accident, the rooks leave the tree. It should be noticed that during the nest-building time the rooks go back at night to their roosting-place, which is usually quite apart from the rookery, but this going to and fro stops when the egg-laying begins, towards the end of the month.

There are usually three to five eggs in a nest, and the mother bird sits very close, the male taking a turn now and then. The colour of the eggs in one clutch is often very different from the colour in another, and this diversity, perhaps due to diet, may have to do with the fact that the eggs are so safe that their colour does not matter much. The nests are so conspicuous that it is of little consequence whether the eggs are or are not. From most enemies, we say, the rook's eggs are safe, but a toll is levied by carrion-crows, which are very successful robbers. It seems rather strange that the rooks should allow this, but they are not very good fighters. Perhaps there is some softness in their character that has led them to be social.

After the eggs hatch, the parents have a very busy time, for the young birds have a large appetite. They are fed on grubs and wireworms and other young insects, so at this time of year the rooks do the farmer a good turn. It is said that in early days the father hands over his collection to the mother, who gives it to the young; later on, both parents feed the young directly, but the mother's contributions seem

Photo : Captain C. W. R. Knight.

NEST BUILDING.

An old nest may be repaired and strengthened, or it may be pulled to pieces and replaced by a new structure.

Photo: Captain C. W. R. Knight.

NEAR VIEW OF ROOKERY.

When the nestlings are ready to fend for themselves, the rookery is left deserted till early in the following spring.

to be most appreciated—why, we do not know.

There is great excitement when the young rooks leave the nest and make their first aerial excursions. And here it may be noticed that rooks often indulge in various kinds of play—gambols and sham-fights and wild chases. In September there is a flitting from the rookery to the roosting-place, where they spend the winter. Or sometimes there is a partial migration to more congenial quarters.

There seems no doubt that rooks have a number of "words," that is to say, different sounds with particular meanings. Between thirty and forty have been distinguished, and we have counted ten at a rookery. One word was uttered when we moved suddenly beneath the trees, and another when a bird went too near his neighbour's nest. There is one word when the rook sinks down upon the nest, and another word when it flies clear of the rookery and makes for the fields. There is most talking, perhaps, at the roosting-place, when the business of the summer is over. "A marvellous medley," said Mr. Edmund Selous in his delightful, book "Bird Watchings," "a wonderful hoarse harmony. Here are shoutings of triumph, chatterings of joy, deep trills of contentment, hoarse yells of derision, deep guttural indignations, moanings, groanings, tauntings, remonstrances, clicks, squeals, sobs, cachinnations, and the whole a most musical murmur. Loud, but a murmur, a wild, noisy, clamorous murmur; but sinking now, softening—a lullaby.

"I never heard so musical a discord, such sweet thunder."

When we went out for a stroll the other evening we saw that the rooks from the small rookery close by were all congregated excitedly on the top of two or three trees which they were not wont to visit. They were protesting loudly, for there, below the trees of the rookery, were two young rooks in full plumage and considerable beauty—but dead.

Now, we do not wax sentimental over a dead crow, but if these young rooks were shot, as we suppose they were, it seems an inartistic act.

Suppose the problematical gunner believes that the rook is a very injurious bird that must be kept down, then he is more than half wrong.

Suppose he dislikes having the cheerful rookery near his house—and it has its crumpled rose-leaves, we admit—would it not be more artistic to blow the nests to smithereens until such time as the rooks shake the dust off their feet and depart?

There is much to be said for the rook, and we think he would say the same of us. For he is distinctly philanthropic. From our point of view,

Photo: S. Crook.

CARRYING A STICK FOR THE NEST.

During the early stages of nest-building, when thieving is common, one of the pair usually remains at the nest while the other collects material. After a while they exchange duties. Among the favourite nesting trees are ash, beech, elm, fir, and sycamore.

Photo: S. Crook.

MALE ROOK FEEDING HIS MATE.

To begin with, the male rook gives over his collection of grubs and the like to his mate, and she gives the surplus to her brood. Later on, he seems to feed the young ones directly, and the hen-bird joins in the collecting. Rooks are monogamous birds.

In the first place, the rook is very handsome with his glossy black feathers that show blue, purple, violet, and green reflections as the light plays on them. Like most strenuous animals, the rook has worked-out pleasant curves on its body, just as a yacht has its thought-out stream-lines. There is an artistic point in having a white to grey patch round the base of the bill, for it "sets off" the head. The disappearance of the bristly feathers round the nostrils and on the chin, which occurs after the first birthday, is not directly due, as some Lamarckians assert, to digging or "howking" in the soil after grubs and such like. It is an engrained constitutional peculiarity, and it is exhibited on birds that have had no opportunity of digging. It is a localised hereditary baldness, and a sign of maturity. Even from a distance, one can tell an isolated social rook from the normally solitary crow by this whitish splash round the root of the bill.

In the second place, there is the admirable flight, with its steady strokes as in a well-rowed boat, much more rapid than it seems. We have often timed rooks as they disappeared over a ridge three miles off in a glen, and, unless there is some optical fallacy, it always came to about a mile in a minute.

But besides ordinary flight, there is extraordinary flight, as when male rooks make nose-dive displays during their courtship. There is often some very pretty aerial gambolling when rooks are in high spirits. It has no meaning beyond play. But there is nothing to surpass the mastery of the air which is to be seen when rooks "shoot" down with half-closed wings on their resting-place or on their rookery. No doubt the rook is a sociable bird. It likes to have its kindred about; it hobnobs with jackdaws; it seems to like to have man as a next-door neighbour, for a great many rookeries are in the vicinity of houses.

Although the rook is the most sociable of European birds, it has not taken great steps towards sociality. We mean that, in spite of its gregariousness all the year round, there is little development of communal life. This is illustrated by the way in which the depredations

of carrion-crows and other marauders are tolerated. A little organisation on the rooks' part would soon put an end to that sort of thing, which sometimes goes so far that the rookery is deserted! It is doubtful whether rooks really post sentinels, and the rooks' "parliaments" that have been described have probably to do with partial migrations. On rare occasions a rook will stand up to a fight, but we think he is at heart a Quaker—a kindly, good-natured believer in non-resistance. Thus while his relatives, except the daws, are in the main solitaries, it has suited the rook's friendly temperament to become very gregarious. "There is safety in numbers," he says. Moreover he is fond of talking.

There is a strong case for giving rooks credit for considerable kin-sympathy, for they will often continue flying near one of their number who has been killed or wounded by a gun. Although they dislike the very sight of a gun, the impulse to stay by their comrade is stronger than fear. Another of their virtues we were almost forgetting—their liking for a bath. This is so keen that it is sometimes gratified amongst the snow. Long live the rook!

Before we change the subject, however, let us take account of the rook's near relatives. Technically it is called *Corvus frugilegus*, and the Carrion Crow is *Corvus corone*, another species of the same genus. The beak of the crow is stouter than that of the rook, and the nostrils are covered with bristle-like feathers, not becoming bare as in a rook that has quite grown up. One must not make too much of the fact that the rook is social and the crow solitary, for a rook may nest away from a rookery and crows sometimes congregate in winter. The two species have different voices. Then there is the Hooded or Grey Crow, *Corvus cornix*, with a conspicuous mantle of grey; but many authorities regard it as not more than a variety or race of the Carrion Crow. The somewhat rare and much larger Raven (*Corvus corax*) and the lively Jackdaw (*Corvus monedula*) are both first cousins of the Rook.

Photo: Langford.

THE NEST COMPLETED.

The nest is built of both dry and supple twigs, with the addition of earth and clay. The inside of the shallow cup is made soft with grass and leaves, hair and wool.

Parrots

Almost all the members of the Parrot order are very social birds, and as conversational as the rooks. Most of them are tropical, and they have very clear-cut characters, so that everyone knows a parrot is a parrot at first glance, though some of the "love-birds" are hardly bigger than sparrows, and the great macaws are three feet long. Among the notable characters we may mention the short, strong bill, with the upper half, movably jointed, protruding beyond the lower and turning down upon it, making a good fruit-opener, also useful in climbing. The tongue is in most cases large and fleshy, and it can be used for gripping food and conveying it to the mouth. The first and fourth toes are turned backwards, the second and third forwards, an arrangement which gives parrots a good grip of the branches. Most of them have a brilliant plumage, and many of them are startling. There are some extraordinary cases, as in Eclectus, where the males are green and the females red. It is the same colouring matter, but the minute structure of the surface of the feathers is different, and that produces the contrast in colour. Parrots frequent forests and grassy plains, and they are rather strict vegetarians—feeding on buds, fruits, seeds, and juicy leaves.

Photo: F. W. Bond.

KEA PARROT.

This remarkable New Zealand parrot (*Nestor notabilis*) is common in mountainous, wooded regions on the South Island. It feeds chiefly on fruits and insects, but sometimes devours the flesh of dead sheep. It is often blamed for attacking living sheep and killing them, but careful observers do not admit that this is more than a rare occurrence. Note the very strong bill.

The most remarkable exception is the Kea or Kaka parrot of New Zealand, which has learned in a short time to kill sheep by tearing off the fleece above the kidneys and gouging out the flesh.

Most parrots have a harsh voice, but their excellence is in their imitative power, which varies with the kind and with the individual, and bears some relation to cleverness. What parrots say often suggests keener wits than they actually possess, for they are trained to utter words and sentences that are particularly to the point in certain situations. A great English ornithologist, the late Mr. Bowdler Sharpe, of the British Museum, vouched for the following tale, which is well known. "A friend in Manchester told the writer of a parrot-show in the north of England where the talking powers of each bird were made the subject of a prize competition. Several of the birds had exhibited their powers, and at last the cover was removed from the cage of a grey parrot, who at once exclaimed, on seeing the company to which he was suddenly introduced, 'By Jove! what a lot of parrots,' an observation which gained him the prize at once."

A grey parrot belonging to an English lady living in Florida showed a keen sense of humour. There were three dogs on the place, each belonging to a different owner. The parrot quite on his own account learned the various whistles which would call these dogs, and would utter each in turn. When the dogs came racing up to the veranda where the parrot's cage hung the bird would fling up its head and utter shrieks of laughter, which was continued while the disappointed dogs slunk away. It was very noticeable that the parrot did not try this trick too often, but only once, or at most twice, in a day. A caller once gave this bird a match which, in biting it, burst into flame. The parrot never forgot or forgave, and months later managed to give this person a severe bite.

Parrots have a great many interesting ways, and we

Photo : James's Press Agency.

GREEN-NECKED AMAZON.

The so-called Amazon parrots are usually green. Most belong to the genus Androglossa or Chrysotis, common in Mexico, the West Indies and South America. The photograph shows very clearly the " tooth " near the tip of the upper bill.

Photo : F. W. Bond.

BLUE CROWNED HANGING PARROT.

The foot in parrots is well suited for climbing and seizing, and also for hanging on by. There is one kind that goes to sleep hanging by one foot. The clinching power is assisted by having the fourth toe permanently turned backwards beside the first.

Photo : F. W. Bond.

GREY PARROT.

The name grey parrot is applied to the members of the family Psittacidæ, confined to Africa and Madagascar. There is a broad, bare " cere " at the base of the upper bill and a naked space round the eye. They are not gaily coloured, but they talk fluently.

Photo : F. W. Bond.

GREATER SULPHUR CRESTED COCKATOO.

Cockatoos usually nest on high trees, but feed in open places. They are very active parrots, flying strongly, taking lively hops along the ground, often digging for roots, and much given to screaming. The plumage is generally looser than in other parrots.

Photo: James's Press Agency.

AMAZON BLUE FRONTED PARROT.

The blue colour is a good example of structural colouration. It is due to the physical structure of the feathers. This gives a blue sheen to a dark pigment that is not in itself blue.

can give only a few illustrations. As Mr. Beebe says in his fascinating book, "The Bird," the feet and toes of parrots come near human hands in the variety of ways in which they can be used—for climbing, for gripping the branch, for holding food to the mouth, for prodding their neighbours, and for preening their own plumage. But they are not good for walking purposes. When a parrot is on the ground and in a hurry to get at something, it waddles awkwardly and often trips up. Then the wings fly out and the bird helps itself along *on all fours*, just like its long-lost reptile ancestor!

Like owls and woodpeckers, to which they seem to be related, parrots lay their eggs in holes in trees. As is usual in such cases, the eggs are white, and we are not surprised to find that in the larger kinds there are seldom more than two or three, for the holes are very safe and the parents guard them. So it is seldom necessary to have a large family. It is interesting that the parrakeets, which are much smaller than ordinary parrots, should sometimes lay a dozen eggs, for they are not in a position to defend them so effectively, and a larger margin is required.

Parrots are emphatically lively birds, full of feeling. Professor J. S. Kingsley speaks of the quick changefulness of the cockatoos in a zoological garden. "At one moment they are climbing about quietly, using both beak and feet in the operation; the next instant they are all excitement, every feather is raised, and the crest is expanded and shut with considerable rapidity. Instead of the soft 'cockatoo,' which they were saying a moment before, they are yelling and screeching in a manner indicative of great passion. The cause of the anger, if anger it be, is usually some inconsiderable trifle, or possibly some person whose appearance or adornment does not suit them."

In many cases parrots show great playfulness. This is well marked in the New Zealand owl-parrot or kakapo (*Stringops*), which has taken to burrowing, and has lost the keel on its breastbone, which every flying bird should have. Mr. A. G. Sale writes: "Its playfulness is remarkable. It will run from a corner of the room, seize my hand with claws and beak, and tumble over and over with it, exactly like a kitten, and then rush back to be invited to a fresh attack." It is credited with a sense of humour, for it shams great anger at a cat or dog, and then shows great glee.

Photo: James's Press Agency.

LEADBEATER'S COCKATOO.

Cockatoos form a family of parrots, mostly restricted to the East Indian Archipelago, Papua and Australia. Most of them are marked by a crown or crest of feathers which can be erected when the birds are excited.

Ways of Woodpeckers

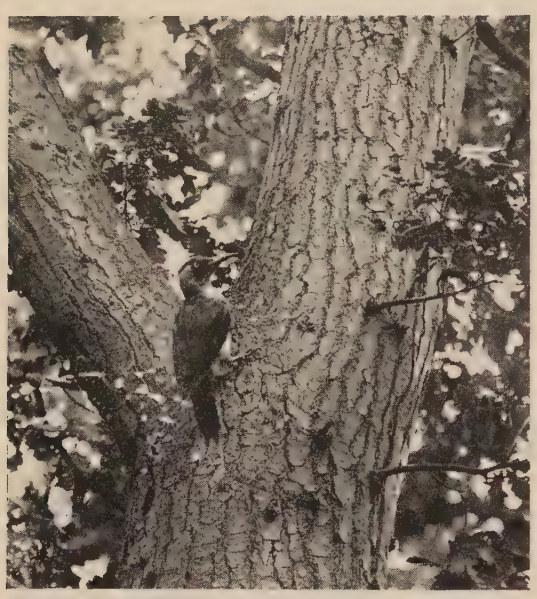
As a further illustration of the ways of birds, let us fix our attention on woodpeckers, of which there are a good many different kinds. In some countries, like North America and well-wooded parts of the Continent of Europe, they are familiar birds. But even when one hears them hammering all round, one cannot always detect them, even when one scrutinises the *under* sides of the branches. They are elusive birds, always on the other side of the tree!

GREAT SPOTTED WOODPECKER.

This shy bird (*Dryobates major*) is distributed throughout Europe and Northern Asia. It is marked by a large white shoulder patch and by crimson on its under surface posteriorly. It has a call-note and an alarm-note, but no song. Both sexes signal by drumming with the bill on a stem or branch.

The most outstanding fact about woodpeckers is that they are so well adapted for arboreal life. The strong-clawed toes are disposed in an unusual way, two forward (the second and third) and two backward (the first and fourth). This arrangement occurs also in cuckoos, owls, and parrots, and must have been evolved several times independently. Its significance is in securing a strong spreading grip, and this, in the case of woodpeckers, makes it safe for the bird to go up the tree stem in a series of jumps, and makes it easy to hold tight during the energetic hammering. Yet we must not overbend the bow, for there are three-toed woodpeckers, both in Europe and America, which flourish bravely. Another adaptive feature is the strength of the main tail-feathers, most of which have stiff shafts and hard webs. When the woodpecker is hammering, the points of the tail-feathers are pressed against the inequalities of the bark, and this must make it easier to hold tight. The ploughshare bone on which the tail-feathers are based is unusually broad, which is as it should be. Then there is the density and pickaxe shape of the beak, well-suited for woodwork; and in correlation with this is the strength of the skull-bones. It must be kept in mind that all birds have surrendered their hand to making a wing, so that much of the work that a hand might do has devolved upon the skull—not forgetting the toes. So it is that the woodpecker uses its skull as a tool. There are three or four different things it does. It makes the bark fly when it is trying to get at insects and their larvæ; in some species it bores holes in order to get at the sugary sap, of which it is inclined to take too much; it fixes an acorn in a cleft and breaks it open; it hollows out a nest in the tree, this being especially the male's task; and, finally, it drums on the dry branch with great rapidity, getting rid of some of its excitement in this way, and, perhaps, sending tidings to its friends. It is plain, then, that a good deal of work has fallen on the skull.

The most striking adaptation, perhaps, is in connection with the tongue. It is not merely long, cylindrical, barbed at its tip, and covered with a sticky salivary secretion that catches insects very effectively; there is an extraordinary muscular arrangement for working it out and in like a flash. In the Green Woodpecker the



GREEN WOODPECKER (*Picus viridis*).
Widely distributed in Europe and Asia, not uncommon in England and Wales, but rare in Scotland. In full light it is very conspicuous with its green plumage and crimson crown.

arrangement is seen at its best ; the muscles of the tongue are fastened to two long curved bones (the horns of the hyoid), which pass backwards and upwards on each side of the windpipe, and continue upwards and forwards in two grooves along the top of the skull till their ends enter the right nasal chamber ! Speaking of the North American Flicker, which well deserves its name, Mr. C. W. Beebe says: " So when this bird stretches out its tongue, the tips of the rear branches leave the opening of the nose and shoot around over the surface of the skull until they have gone as far as possible," which may be two or three inches beyond the tip of the beak. As the flicking in is even more rapid than the flicking out, it is evident that the ants have not much chance when the Flicker visits their hill. And we get a biological glimpse of Nature's way of making new things out of very old things when we remember that these extraordinarily elongated hyoid horns of the " laughing yaffle " correspond to the third pair of gill-arches in a fish ! They are transformations of these ancient structures, turned to a use as different as different could be.

There are some kinds of woodpeckers which feed on sap more than on insects, and it is interesting to notice that they have rather short tongues with a brush-like instead of a barbed end.

A very interesting feeding habit in the California Woodpecker has been carefully studied by Professor W. E. Ritter and others. When the acorns are ripe on the trees the woodpeckers collect them and push them into holes in the branches. There they can be more readily broken open or they can be left as a store for days of scarcity. Sometimes there are many hundreds of acorns on one tree, tightly fitted in suitable holes or in holes that have been drilled to suit them. It is not difficult to understand that the habit woodpeckers have of pressing a hard fruit into a crevice and then breaking it might be improved upon by making suitable holes and by gathering a large store. Inside the acorn there is often a grub, and this is sometimes eaten by the woodpecker, but the bird is mainly interested in the acorn itself. Most of the acorns are plucked off the trees, but some seem to be picked up from the ground. One of the points that requires further investigation is that many trees, e.g., pines and oaks, show numerous *drilled* holes, and yet not an acorn in one of them, although there were available acorns in abundance. Not very surprising—for there are many similar instances among storing animals—is the fact that hundreds of acorns plugged into holes are left unused. Some of them decay, some of them are treasure-trove to squirrels and climbing rats.

In searching for insects the bird jerks itself rapidly up the stem, but pauses at intervals to look round in a very alert way, well shown in the photograph.

One would think that the eggs were very safe in the hole, but the bird seems nervous. Starlings are sometimes bold intruders.

Storing is very rare among birds, but there seems no doubt that it is well on the way among these woodpeckers, and it may be that some of the peculiarities in the harvesting of acorns are due to the fact that the instinctive prompting is still at a tentative stage. We are apt to go wrong by thinking too much of evolution in the past, for it is going on here and now, and woodpeckers are particularly interesting because they illustrate so well the evolving organism's way of sending tremulous tendrils into the possible, feeling for something to which to fasten. There are insectivorous woodpeckers, frugivorous woodpeckers, bibulous sap-sucking woodpeckers, and more besides ; they are testing all things, and many of them have determined to hold fast that which is good. But there are others—organically restless, variable, experimental, such as these California Woodpeckers ; and when a structural variation, like a lucky card in a " hand," is played effectively by a hustling creature in the " struggle for existence," then there is evolutionary advance.

From this point of view it is easier to understand the extraordinary mistakes which the storing woodpeckers sometimes make. They are not attending their minds thereunto in an intelligent way, they are obeying instinctive promptings ; and at present it does not seem to be of vital consequence whether they store successfully or not. What mistakes do they make ? They sometimes store other hard things besides acorns, and when these are nuts or almonds the birds cannot be said to give themselves away. But what are we to make of the not very rare cases of storing pebbles instead of acorns ? The incipient instinctive prompting has still a somewhat blunt point. The Central American counterpart of the Californian Woodpecker sometimes drops its acorns into places from which they cannot be retrieved. Mr. Morton Pack writes from British Honduras : " I have seen a hollow pine tree with a cavity six or eight inches in diameter filled for a distance of nearly twenty feet with acorns dropped into a good-sized hole at that distance above the ground." Such acorn-filled trees are not uncommon, and their contents may represent the accumulated savings of years. The woodpecker's storing instinct has still a good long way to evolve !

Returning to Britain, we cannot but admire our woodpeckers' nesting. Having discovered by tapping that a tree is decayed at the core, the bird, usually the male, proceeds to make a horizontal porch. He works very quickly, and the chips accumulate on the ground. When a few inches have been excavated a vertical shaft is sunk in the heart of the tree, perhaps a foot deep.

NEST OF GREEN WOODPECKER IN STORM-SHATTERED TREE.

Five to seven glossy white eggs form the clutch. White is a common colour for the eggs of birds that lay in dark places.

On the floor of this chamber, on a layer of chips, the five or so eggs are laid, very beautiful in their glossy whiteness—white eggs being common in dark nests. The young ones, hatched about May, are naked and helpless at first, and they skip the downy stage. They look rather like young hedgehogs when the feathers are sprouting. Strength comes quickly, and they clamber inside their hole to meet the parent bringing a mouthful of food. Perhaps the decaying wood makes the nest more wholesome than it would otherwise be, but it becomes very stuffy and worse; and skilled observers have had the good fortune to see the young woodpeckers taking an airing on the branch before they are ready to fly.

XV

CONCERNING PUFFINS

THE common puffin is a member of the very well-defined family of auks, which includes little auks, guillemots, razorbills, and, of course, the extinct great auk. They certainly have a strong family resemblance in shape and carriage, which points to their being adapted to an open-sea life, for swimming and diving even more than for flight. Not that they do not fly well enough, but the wings are short and narrow, and there is something ominous in the doom of the great auk, which was in part due to its having lost the power of flying. Most of the auks are black and white; most of them breed gregariously on precipitous cliffs and rocky islands, dispensing with a nest; most of them depend in the main on fishes; all of them are birds of the north. They form a family worth knowing.

There is a peculiar charm about the puffin, though he is not so much of a "character" as he looks. In a recently published account of diving birds (U.S. National Museum, Bulletin 107, 1919), Dr. C. W. Townsend gives us the initial picture we need: "The puffin is a curious mixture of the solemn and the comical. Its short, stocky form and abbreviated neck, ornamented with a black collar, its serious face and extraordinarily large and brilliantly coloured bill, suggestive of the false nose of a masquerader, its vivid orange-red feet and legs all combine to produce such a grotesque effect that one is brought almost to laughter on seeing these birds walking about near at hand." To watch a thousand of them at midsummer on such breeding places as the Bullers of Buchan is to enjoy one of the most cheerful spectacles in the world.

Photo: W. S. Berridge, F.Z.S.

PUFFIN SITTING.

This very distinctive bird (*Fratercula arctica*) has a laterally compressed bill, covered with brightly coloured scales which are moulted annually before winter comes.

They are fortunate in most of their many names, for puffin sounds all right ("*a naturali voce*," an old writer says), and the appropriateness of "sea-parrot" and "coulter-neb" (like the fore-

iron of a plough) is clear. There is a suggestion of mingled affection and amusement in "Tammy-Norie," but most of all we like the Linnæan technical title *Fratercula arctica*, our "little brother from the north." As everyone knows, the puffin is a summer visitor to our coasts, arriving in April or May in huge numbers, and with great local punctuality, staying for the breeding season, and disappearing again about the end of August for its real home in the more or less open sea. In one locality in the Hebrides, Professor Newton estimated the puffin population during the breeding time at about three millions, but the confiding and simple nature of the bird has played into the hands of ruthlessness, and the result has been a terrible thinning of its cheerful ranks in most parts of the world. There was some excuse in old times, when the plump birds were eaten; there is very little excuse now.

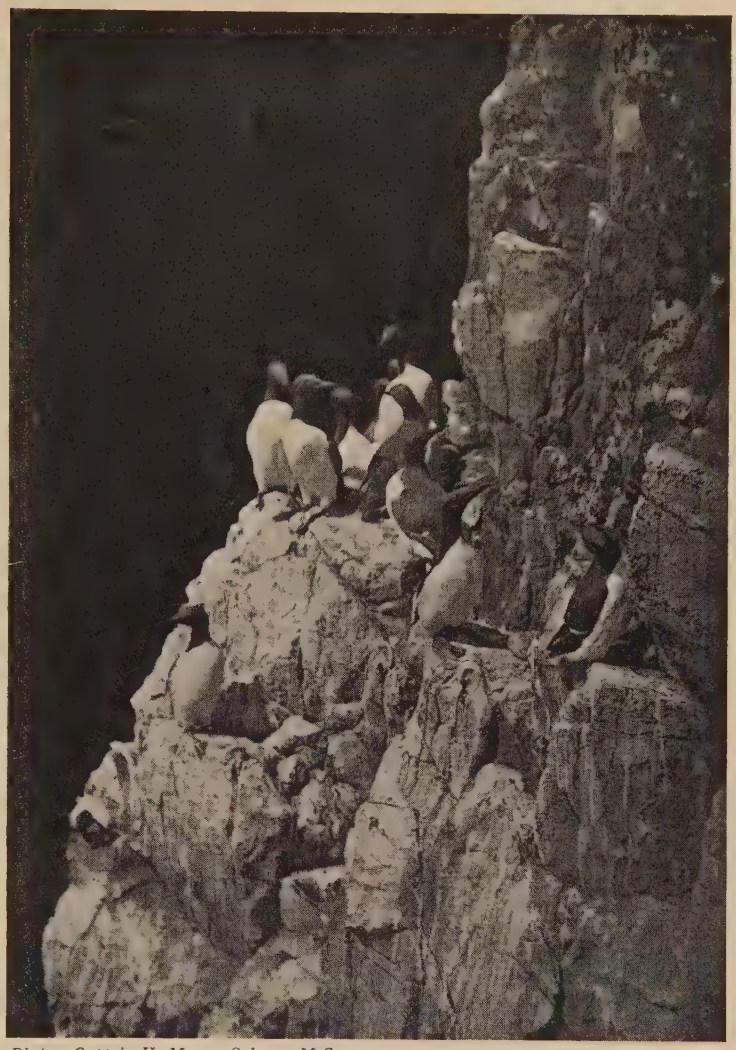


Photo: Captain H. Morrey Salmon, M.C.

GUILLEMOTS ON THE NESTING CLIFF.

This common gregarious sea-bird (*Uria troille*), of the Northern Atlantic and Pacific, breeds on steep cliffs and winters in the open sea. It flies well, swims well, and dives well, using its wings under water. It may be distinguished from its relative the razor-bill (*Alca torda*) by the longer neck and the sharp-pointed, not laterally compressed, bill. One egg is laid on a bare ledge of rock.

As they stand at "attention" on the cliffs, puffins look as if they were on their tails, but that is, of course, an illusion. They stand on their feet like other birds, and when they walk about in their quaintly dignified way it is only at times that more than the toes are on the ground. From the bolt-upright position the body often sinks down to the horizontal, like that of a duck, and when they are about to spring from the cliff, the instep, as well as the toes, may be pressed against the rock. The flight is rapid, and the quick beating of the little wings makes a whir; great curves are often described, and baffling zigzags; the orange-red webs of the toes are spread out to each side when the birds alight with a splash in the water.

It is delightful to watch score after score launch themselves, wings up and heads down, from a high cliff, whir close past one, and, after a fine sweep, reach the crowd already bobbing in the sea. "On the surface they paddle along skilfully, like little apoplectic short-necked ducks, and their small orange-red legs are plainly visible. Their diminutive tails are sometimes cocked up at an angle." But perhaps the most interesting fact in regard to the puffins' movements is that they fly under water, the feet trailing behind, just as in aerial locomotion. This is true of other members of the auk family, but some use feet as well as wings in diving. It is rather striking that the puffin's movements of propulsion should be much the same in

Photo: C. J. King & Son, Scilly.

THE PUFFINS' PLAYGROUND.

Showing hundreds of the birds resting and swimming on the water.

swimming under water and in flying, but one remembers that land-mammals, when tumbled into the sea, usually swim by continuing their walking movements, a method which, unfortunately, does not work in our own case. Another point is that the puffins in flying under water are doing what the penguins of the south, with which they have no relationship, practise so skilfully; and that the water-ouzel or dipper, has begun the same sort of habit. This was not the way with the extinct *Hesperornis*, a toothed aquatic bird about five feet long, which swam by strokes of its powerful legs, and had wings dwindled almost to a vanishing-point. Unless helped by a strong head wind, puffins seem to have considerable difficulty in rising from the water, and they often splash along the surface for some distance before they get launched into the air. But when they are fully a-going they fly well.

Dr. Townsend notices a very interesting point: "Flocks wheel and turn together with the regularity of shore birds, now showing their black backs, now flashing out their white breasts and bellies." This is a striking Natural History corroboration of what the anatomists tell us, that the auks are related to the plovers. But the resemblance in mass-flight between the two groups is almost the only point in which their habits agree. How different, for instance, are the voices, for the puffin, though not very talkative, purrs and croaks, laughs in its throat and groans. We concealed ourselves once where puffins nested, and we rarely heard such sounds. In fact, we have always been afraid to speak of them, and would not have dared now had we not come across the description given by Mr. Edmund Selous: "The note of the puffin is very peculiar—sepulchrally deep, and full of the deepest feeling. Another note is much more commonly heard, namely, a long, deep, slowly rising *awe*, uttered in something of a tone of solemn expostulation, as though the bird were in the pulpit."

When puffins come to our shores at the beginning of summer, they come to mate and breed, but first there is the courtship. Dr. Townsend writes: "They swim together in

closely crowded ranks, rarely diving, for their thoughts are not on food. At frequent intervals individuals rise from the water and flap their wings as if from nervousness. Again, two males fight vigorously, flapping their wings meanwhile and making the water foam about them. Again two, possibly a pair, hold each other by the bills and move their heads and necks like billing doves. Now several are seen to throw their bills back with a jerk until the bill points up, and this is repeated several times." Mr. Selous notes that although the bill is opened wide, no sound is uttered. The inside of the mouth is brilliant yellow, and the display of this probably forms part of the courting ritual. It is at this season that the bill is at its best, and it is extraordinary in its colouration. There is a mingling of bright scarlet, steel blue, orange, and white, while the edge of the eyelids is a vivid vermilion. The sparkling eyes themselves are blue-black. If the brilliance of the bill is connected with courtship, as some ornithologists suggest, it is remarkable in being the same in both sexes !

But the most interesting thing about this wonderful bill is that the brightly coloured sheaths are moulted every year. This is seen in other kinds of puffin, and in some measure in some more distantly related birds, such as the razor-bill. When the shields fall off, there is a change in the shape of the bill and a reduction of the size to about a half. There is also a moulting of the little horny outgrowths above and beneath the eyes. Before the next breeding season all is restored. Whether the curiously grooved and embossed shields, which are of use in fish-catching and fish-carrying, get worn and loose, e.g., in fighting, and require renewal more than in other birds, we do not know; but the peculiarity, like the shedding of the claws in grouse, takes our thoughts back to the moulting of the scales in reptiles. The horny encasement of the bird's beak, often consisting of a good many pieces (about nine in the puffin) is undoubtedly a legacy from reptilian ancestry, and the puffin's annual bill-moulting is a disclosure of pedigree.

Photo : C. J. King & Son, Scilly.

BRINGING FOOD TO ITS YOUNG ONES.

The puffin may have four or five fish neatly arranged crosswise in its beak. How does it add to the number without losing all ?

Photo : C. J. King & Son, Scilly.

A GROUP OF PUFFINS,

resting on a rock near the shore. The bird stands on its toes like an ordinary bird; it does not rest on the instep (metatarsals) as well as the toes, as a guillemot does. It walks with "a nautical roll."

Another peculiarity concerns the egg-laying, for while almost all auks lay on a bare shelf, the puffin is a burrower or utilises a hole made by a rabbit. The burrow is often just about

the length of one's arm—a statement not to be verified without gloves if the puffin is at home. When it has to be made, it is chiefly the task of the male, who uses his toe-nails with zest. A burrow may have two doors, and several burrows sometimes communicate. At the extreme end is a rough nest of dry grass, sometimes with a few feathers, and in this there is usually a single egg, dull white in colour, occasionally blotched. The contrast between the whiteness of the hidden egg of the puffin and the many colours of the exposed egg of the guillemot or the razor-bill is very striking. We wonder whether we should say that hidden eggs are usually white or that white eggs are usually hidden—a question dividing Lamarckians and Darwinians still. Both parents brood, but the mother seems to be the more assiduous. Hatching occurs in about a month, and after that the young one has to be fed for four or five weeks. The parents bring in fishes, two or three inches long, several —up to eight—at a time; and these are held crosswise in the mouth. It is difficult to understand how the number is added to without losing previous captures; but it may be that the tongue and some spines in the mouth keep hold when the jaws are opened. The young bird's first coat consists of long, soft, thick down, brownish-black above and whitish below; this gradually gives place to the characteristic black and white plumage. When summer is over there is not a puffin to be seen on the cliffs where there were thousands—the young have followed their parents to the open sea.

Photo: W. S. Berridge, F.Z.S.

A NESTLING PUFFIN.

It has long, sooty down, with a whitish patch below. Later on it becomes greyer, and the slate-grey legs become pinkish. It is an active nestling and it pipes when the parent arrives with a mouthful of fish.

Mr. A. C. Bent has given us, in the monograph referred to, a very interesting account of other puffins. There is the so-called horned puffin of Alaska and the Behring Sea, which shows above its eye a soft raisable excrescence, represented by a small process in our "Coulter-Neb." In certain localities the horned puffin's tunnel has always two openings, which are used indiscriminately, and the "nest" may be at almost any distance from two to ten feet from the face of the bluff. The young bird is taken by the parent from the nest before it is quite able to fly. The bill is partly used in climbing, and this seems to wear and loosen some of the plates. Nearly related is the tufted puffin of the North Pacific, which breeds on the Aleutian Islands, where it is very welcome to the Aleuts as a change of food after a winter of salted seal. The skins are made into a warm and light hooded garment, worn with the feathers to the inside. The faces are white, and there are flowing white plumes on the head which suggest snowy locks, and explain the popular name, "old man of the sea." The tufted puffin uses

Photo: C. J. King & Son, Scilly.

THE PUFFIN'S BURROW.

This may be a rabbit's, but it is usually excavated by the bird itself. The bill is the pickaxe and the feet scratch the débris outwards. There is no uniformity as to length of burrow; it varies from several inches to a few feet. Sometimes there is a back-door, and it is much needed.

feet as well as wings under water, but it is not fond of diving. It is an extraordinarily hardy bird, very tenacious of life, voracious and aggressive; it holds on like a bulldog with its jaws, and is able to bite to the bone with its bill. We do not wonder that some ornithologists insist that it should not be called Fratercula.

XVI

THE MIGRATION OF BIRDS

MIGRATION is illustrated by many animals, but birds show it best. It is a swing from a breeding and nesting place to a feeding and resting place. It is like a tide setting in from the south in spring, ebbing from the north in autumn.

§ 1

The Main Facts.

Everyone who lives in a north temperate country like Britain, notices that there are comparatively few different kinds of birds to be seen in winter. There may be many sparrows, many rooks, many redbreasts, and so on, but the majority of kinds have gone, seeking more genial quarters in the south. But they return in spring, with spring in their voices. In the Northern Hemisphere migration is the rule.

But it occurs in very diverse degrees. A flock of curlews may simply migrate in autumn from the exposed moorland to the low grounds near the shore, whereas the swallows may fly from Britain to winter quarters far south in Africa. The lapwings or peewits may migrate in autumn from the north of Scotland to the north of Ireland, where the winter is much milder; but the Virginian plover flies from Labrador in the north to Central America. The Pacific golden plovers, which spend most of the year in the Hawaiian Islands, which are about two thousand miles away from everywhere, fly north to Alaska to breed, finding their way mysteriously over the pathless sea.

In any north temperate country there are always to be distinguished five sets of birds, considered in reference to migration. (1) There are the *Summer Visitors*, arriving in spring, nesting in their summer quarters, returning to the south in autumn. As examples of this very large company, many of them songsters and most of them insect-eaters, may be mentioned swallow, swift, cuckoo, nightingale, and warblers. (2) Then there is the much smaller company of *Winter Visitors*, that breed in ordinary circumstances in the Far North, and find a country like Britain a pleasant place for the winter. Such are the fieldfare and the redwing, both first cousins of the thrush, but never nesting in Britain. Such also is the snow bunting, on rare occasions nesting on mountains in the north of Scotland. Many northern ducks and divers belong to this group. (3) Third, there are the birds-of-passage in the

Photo: Albert Henry Willford.

SWALLOWS RESTING.

This familiar ever-welcome bird is a typical summer visitor to Britain. They first arrive in England about the middle of March (May for Scotland), and the height of the autumnal migration is in mid-September. The main trend of the route to winter quarters is from north to south. The swallow has a blue back, chestnut and blue breast-bands; the house-martin is white on the rump and beneath.

stricter sense, such as the great snipe, the little stint, and some of the sandpipers, which rest on British shores for a short time on their way farther south or farther north. (4) Fourth, there is a large group of what are called " partial migrants." These are birds which never leave the country altogether, but some of them migrate, while others stay on. There is no month of the year when there are not many lapwings and goldfinches to be found in Britain, yet some lapwings and some goldfinches migrate. In some cases the birds of a particular locality move southwards and their place is taken by another set of birds of the same kind, which come from farther north. (5) There remain the strictly resident birds, which do not migrate at all, such as in Britain the red grouse, the house sparrow, the dipper, and the redbreast.

So that, from the point of view of migration, the birds of a north temperate country may be grouped into summer visitors, winter visitors, birds-of-passage, partial migrants, and residents.

Brooding birds and young nestlings are apt to suffer from the heat of the sun, and it is thus easy to understand why migratory birds always nest in the coldest part of their range. There are, of course, many birds that are accustomed to live permanently in the tropics, but the migrants that come to the north in spring require a cooler place for nesting. Some birds seek out a nesting place so far to the north that the eggs are seldom seen, and those of the knot are notable rarities.

Photo : New York Zoological Society.

WILD DUCKS, ON AN OKLAHOMA LAKE,

alighting for rest in the evening during their journey south. In many countries wild duck are known as gregarious summer and winter visitors. They breed, as is usual with migrants, in the colder part of their range. Thus the wigeon, which nests in Scotland and through North Europe and Asia to Alaska, may be found in winter as far south as Madeira, Abyssinia, Borneo, Polynesia, and American coasts.

In the spring there is in the Northern Hemisphere an arrival of immigrants from the south or south-east. The full-grown males often arrive first, and they sometimes, as among the warblers, choose a tree which will be the centre of their summer " territory " —that is to say, if their mate approves of the site. The full-grown females follow on the heels of the males, or may arrive along with them. Last of all come the young birds that will not nest for another year or more.

The autumn tide not infrequently shows a different order, for the younger birds sometimes leave first, starting off on a long journey, which many of them at least have never made before There is a well-known exception in the case of the cuckoo, for the parents leave their summer quarters a month or more before their offspring are ready. There is nothing to hinder the parent cuckoos from migrating, for they have handed over all their responsibilities to the foster

Photo : G. C. S. Ingram, M.B.O.U.

REED WARBLER AND YOUNG.

A good instance of a summer visitor to England. This vociferous bird of the reeds (*Acrocephalus streperus*) builds its nest round living stems, which raise it as they grow. The young birds are very clever in threading their way amongst the reeds.

Reproduced by permission of "The Sphere."

ST. CATHERINE'S LIGHTHOUSE,

showing perches put up by the Bird Protection Society—also at South Bishop, Spurn and The Caskets. The object is to allow the birds to rest for a moment when they are attracted to the light. If they have not violently knocked against the glass, they may take advantage of the perch to recover themselves.

parents, such as meadow-pipits and hedge-sparrows. As some of the foster-parents are not migratory birds, it looks as if the young cuckoos would sometimes have to make the journey to the south quite unaided. It is very difficult to understand this making for an unknown goal. Another reason why the parent cuckoos should hurry away is that the caterpillars they are so fond of are becoming very scarce.

For some birds it has been noticed that the departure in autumn is very leisurely. They are like people who say good-bye many times. They flock together, take trial flights, then settle down again. This is different from the arrival in spring, when they seem to be more in a hurry. Audubon notices that the American rice-bird flies by night in spring, and by day in autumn.

The migration has been going on for many thousands of years, and it has become very regular. It is said that some Indians name the months from the arrival of certain characteristic birds, and ancient writers have commented on the regularity of the movements of the birds. "The stork in the heavens knoweth her appointed time, and the turtle, and the crane, and the swallow observe the time of their coming." Just as there is considerable regularity in the flowering of certain wild plants in different parts of the country, so is it with the arrival and the departure of the migrant birds. In both cases the constitution of the creature has been, as it were, wound up to become restless at particular times of the year, but this is linked on to the regular changes of the seasons. The dates may be shifted forwards or backwards according to peculiarities in the weather at a particular place or in a particular year. It is the same with the blossoming of the flowers.

It is not only in their punctuality that migratory birds are remarkable; they sometimes come back to the same breeding place year after year. This has been known for a long time in connection with storks, but it has been recently proved up to the hilt for a number of other birds. The sure way of proving a fact like this is to mark the bird in some unmistakable way, and then to watch for its return the following year. A good method of marking is to attach to the bird's instep a light aluminium ring, with a break that can be opened and then pressed firm again. On the ring there is printed some name or number. If the proper size of ring is selected, and if it is not put on till the bird is nearly ready to fly away—when the growth in the thickness of the instep is almost finished—no harm will be done to the bird. A swift that was "ringed" in Ayrshire in 1914 was recaptured in the same place in 1918, having doubtless been to Africa four times in the interval. The presence of the ring with the address and the number was certainly proof up to the hilt!

MIGRATIONS OF THE SWALLOW (after Lincoln).

The places where the birds were ringed are indicated by spots enclosed by circles. The dark spots indicate the places of recapture. Seven returns for birds banded in England were from South Africa, indicating an air-line distance of over 7,000 miles. But it must be understood that what is still very vaguely known is the route the birds followed in reaching these winter quarters.

Photo: G. C. S. Ingram, M.B.O.U.

YOUNG TURTLE-DOVE.

The migratory turtle-dove (*Streptopelia turtur*) breeds in woodlands and forests in the northern parts of Europe and Asia, and spends the winter in Africa. In many parts of Britain it is only a bird of passage. It builds a nest of slender twigs at no great height and lays two white eggs. Even the squab has considerable combativeness. The deep vibrating notes of the full-grown bird are well known.

Similarly, a swallow marked in Aberdeenshire in 1912 came back with its ring the following year, not only to the same county and parish, but to the very farmsteading which was its birthplace. No doubt many birds go utterly astray during migration, especially when the weather is stormy, but the sample facts we have given show how very exact the journeying may be. There can be little doubt that migrant birds have a very striking "homing" power, of the same rather mysterious nature as the ability of carrier pigeons to return to their owner from great distances.

§ 2

There are two main ways of finding out where migrant birds go when they fly south or south-east in autumn, or of finding out what route they take, or of answering similar questions. One way is to collect facts from careful observers on lighthouses, lightships, islands in the sea, passes among the mountains, and so on. For the observers can tell us, for instance, that on a particular date at the end of summer they saw a great crowd of wheatears, let us say, flying due south. A great many observations of this kind have been collected both for the autumn and the spring flights.

The Paths of the Birds.

The other way is to attach to the instep region of the foot, as we have already mentioned, a light aluminium ring, with an address and a number stamped on it. A small percentage of birds with these rings are afterwards shot or trapped by people who are interested enough to send to the address on the ring a note of the place where they found the bird, and the date. Thus there may be built up a knowledge of the paths that are followed in migration.

Dr. Thienemann, of the Bird Watching Station at Rositten, on the Baltic, near the boundary between Germany and Russia, arranged for rings being placed on the feet of a large number of storks in north Germany. Some of these birds were afterwards heard of, and the rings returned with a note of the place and time of capture. When Dr. Thienemann got a ring returned from, let us say, Lake Chad, in the centre of Africa, he put a cross on his big map. When another ring came from the Blue Nile and another from Basutoland, more crosses were registered on the map. In this way there was gradually established a trustworthy record of the path taken by the north European storks in their autumnal flight, e.g., from north Europe to Egypt, and along the line of the Nile Valley southwards. The same has been done with many different birds, and though the inquiry is still young there is a gradually growing knowledge of the winter quarters of North Temperate birds and of the routes the birds take to get there.

Let us notice some of the routes in Europe. Numerous birds congregate in autumn along the southern shores of the Baltic and make their way westwards. Some bands swerve southwards, following the valleys of the Rhine and the Rhône, and thence pass over the Mediterranean to North Africa. Other bands go further westwards, cross to Heligoland, rest there for a night, continue to the south of England, and pass thence along the coastlines of France, Spain and Portugal to the Mediterranean, and thus finish up again in North Africa. In some cases, like the swallows, there is evidence of a more directly southwards flight from north Europe.

Many birds foregather in eastern and central Europe, come down to the Adriatic, follow either coast to the southern end of Italy, and cross the Mediterranean via Sicily to Tunis. Others, collecting in Hungary, Austria and southern Germany, pass to the south of the Alps across the north of Italy, e.g., along the basin of Po, and eventually reach North Africa by following the coastline of France and Spain, or by crossing the Mediterranean by Corsica and Sardinia, or by the Balearic Islands.

One should not think of the migration-routes in a hard and fast way. They seem to be broad paths, so far as we can judge from our scanty knowledge. Birds of the same kind may winter in different places even when they hail from the same breeding area. The route is often roundabout, and there is great diversity among individuals. Some go much further than others of the same kith and kin. What we call their "goal" is in part determined by the length of flight that can be readily attained. Some will stop in autumn when they reach the shores of the Mediterranean, while others of the same species will go far into Africa. There is a good deal of flexibility in migration.

§ 3

It is a striking sight to see from a ship an enormous cloud of birds sweeping along like smoke at no great height above the waves. Larks, starlings, and thrushes are sometimes seen flying low in this fashion. But this is not the way with most birds. Much nearer the average is the beautiful and not uncommon sight of a great V of wild geese making their way northwards in spring in a flight that often keeps pace for a time with a railway train. Thanks especially to the careful observations of airmen, we now know that the great majority of migrants journey at an altitude below 1,300 feet, and that flight above 3,000 feet is very rare. Geese, cranes, and storks are good examples of high-fliers. Airmen with ornithological experience have recorded a swallow at about 1,000 feet and another at 1,400, a flock of rooks at 1,650, two storks and a buzzard at 2,800 feet, a flock of cranes at 4,500, a lark at 1,000, and another at

Altitude and Velocity.

Photo: G. C. S. Ingram, M.B.O.U.

HERONS AND YOUNG (*Ardea cinerea*).

The nest is a big platform of sticks, with softer material for lining. It is usually built on a high tree. The four or five nestlings are half-naked for a long time and have short, blunt bills.

6,000 feet. The great heights reported for "sailing" vultures stand by themselves and have not to do with migration. It may be noted that ordinary birds seem to be even more sensitive than mammals to the difficulty of breathing at great altitudes.

There has been a good deal of exaggeration in regard to the height at which migratory birds travel, and the same is true of the rate of flight. A carrier-pigeon has been known to fly at the rate of 55 miles an hour for four hours on end, and it would be safe to say that many a migrant bird keeps up the rate of half a mile a minute for a considerable time. Careful estimates of the time taken between two points connected by telephone gave 30, 32, 37, and 46 miles an hour for crow, finch, peregrine falcon, and starling respectively. A quickly-flying snipe, *with the wind in its favour*, has been known to come near a mile a minute, and many birds can do the same. But the usual pace is probably much less. It must be remembered that when a bird has got up a good pace its flight becomes very much easier, and it is plain that ordinary birds cannot rest when crossing a great stretch of sea. On the other hand, it appears that even a strong flier like the stork is not inclined to go on too long. It does a fair day's work when it covers 125 miles in autumn and 250 in spring; and it does not usually care for more than a six-hour day. A coot has been known to cover 160 miles on each of two successive days, and woodcock 250–300 miles in one short night. Plover are said to attain to about 550 miles in an eleven-hour day, and there is a well-authenticated story of a marked redbreast which travelled 700 miles in 22 days, that is about 32 miles per day.

What a contrast this is to Gätke's stories of hoodie crows crossing 375 miles of North Sea in three hours, or of the little blue-throat journeying from Egypt to Heligoland in a single night of nine hours, which meant a velocity of over 200 miles an hour. Recent estimates are wholly against the acceptance of such estimates, but it is probably safe to say that many migrating birds can keep up a rate of 30–40 miles an hour for several hours in succession. When the wind is against the bird, the rate of flight is greatly reduced and the cost to the bird is greatly increased. Every bicyclist knows that against the wind he must go much more slowly, and that he gets much more quickly tired.

§ 4

How Migrating Began.

This see-saw between two homes—the summer quarters and the winter quarters—how did it begin? Perhaps part of the answer to this difficult question is to be found in the changes of climate that have occurred from time to time. We know that the north of Europe enjoyed for a long period a more genial climate than it has now. There are, for instance, remains of palm-trees and magnolias where these plants can no longer flourish. In those genial days it is likely that the list of resident birds in a country like Britain was much longer than now. It was all the same to the birds whether they stayed in Greenwich or Greenland. But the climate became gradually colder and colder—the Ice Ages set in. Enormous snow-fields covered the north and huge glaciers formed on the mountains. By slow degrees, century after century, most of the birds had to move southwards as the winter drew near. Those that were too dull or sluggish to take the hint would be weeded out, and the same fate would befall those that lost their way hopelessly. The wiser and the cleverer birds would survive and lead the race. In the summer time there would be a return to the valleys when the snow melted, and the birds probably enjoyed berries and mosquitoes just as those do that go to the north of Scandinavia every summer. But the state of affairs became worse and worse. Almost the whole of Britain, for instance, was covered deep in snow and ice, and all the fine mammals like cave lion, cave bear, mammoth, and woolly rhinoceros, which used to be British, were destroyed or driven south. There were four of these Ice Ages, with three milder periods in between, and we think it may be safely said that some of our present-day migratory birds learned the lesson in these times very long ago. Of course we must not think of birds sitting down and cudgelling their brains over the problem presented by the terrible ice-sheet drawing nearer and nearer to their pleasant home. They did not emigrate after deliberation like the Pilgrim Fathers. It was probably in a slower, much less conscious way that the

STORY OF THE YOUNG CUCKOO

Photo: S. Crook.

The common cuckoo winters in Africa and Southern Asia, coming to England in April. Making no nest of its own, it lays its eggs in the nest of another species, often that of the meadow-pipit or hedge-sparrow, to whom is left the hatching and rearing of the young. Here we see a cuckoo's egg—the larger—in a meadow-pipit's nest.

Photo: S. Crook.

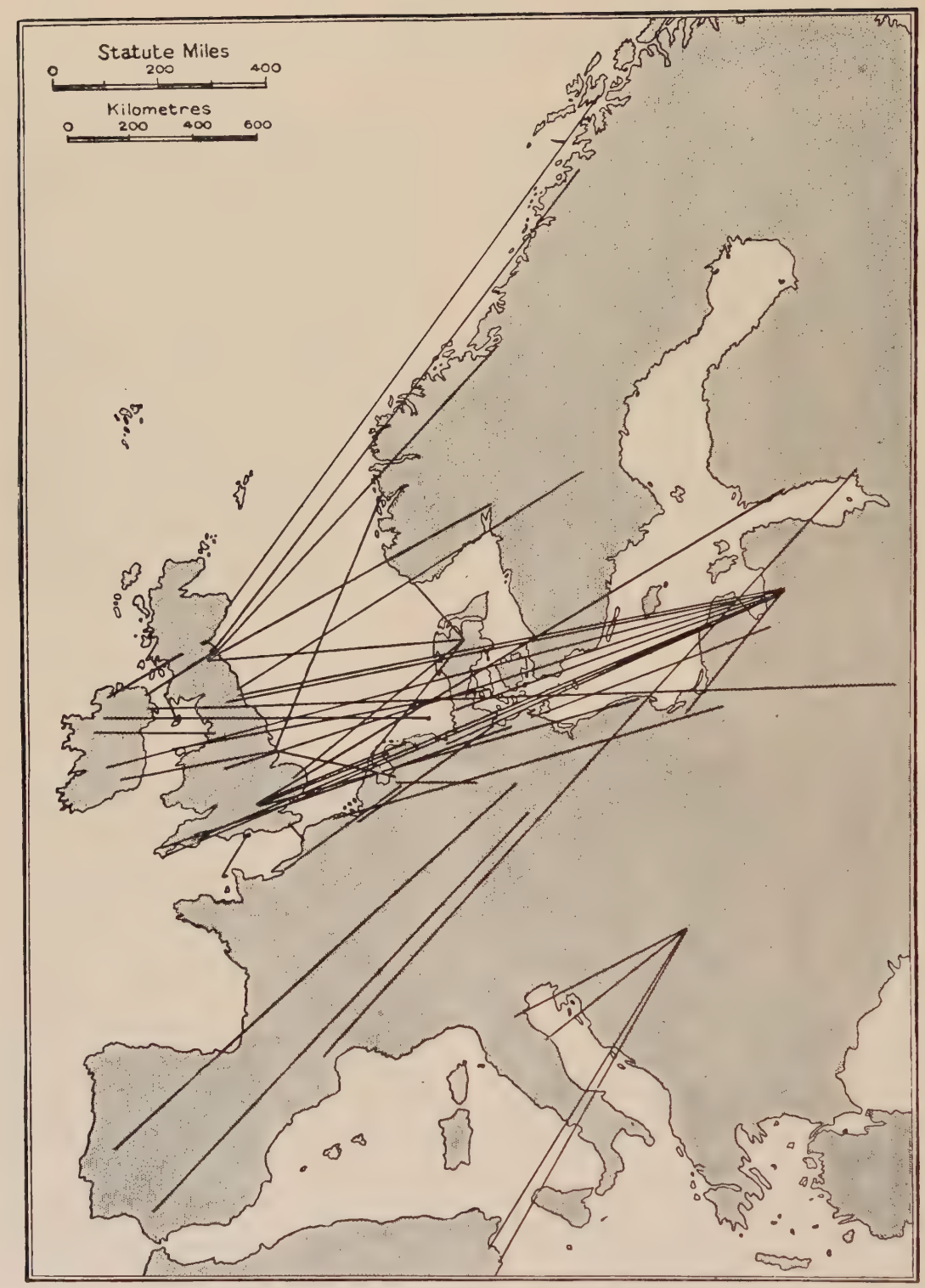
The young cuckoo gives considerable trouble to its foster-parents. When hatched, although blind and naked, it tries to eject the other fledglings. When it hatches first, as is sometimes the case, it proceeds to push out the foster-parent's eggs. In every case it is the sole survivor in the nest.

Photo: Albert Henry Willford.

The young cuckoo when fledged leaves the nest of the foster-parent, but for a long time refuses to fend for itself, waiting greedily for the tiny meadow-pipit to feed it.

Photo: Albert Henry Willford.

It has a voracious appetite and keeps the foster-parents hard at work to satisfy its needs. The illustration shows how much smaller the meadow-pipit is than its charge.



After Dr. A. Landsborough Thomson.

THE MIGRATIONS OF MARKED STARLINGS.

Each straight line on the map connects the place of ringing and the place of recovery of a marked starling. The records are taken from both British and foreign sources, but only the principal cases—those showing long-distance or overseas journeys—are included.

(*The lines are NOT intended to indicate the actual routes followed.*)

Photo: Albert Henry Willford.

EGGS OF LESSER TERN.

There are usually two or three, stone-coloured with brown and grey markings. They are conspicuous on sand; very inconspicuous among stones.

custom began and grew. Birds, like most animals, are given to making experiments, and those that made the experiment of taking a long flight southwards when the pinch began to be felt in the fall of the year, would be the successful survivors. Gradually the experiment became a custom of the particular kind of bird, and was engrained in its constitution. It may seem a hard saying, but it is almost certainly true, that birds do not take thought for the morrow.

But without going back to the Ice Ages, which began several hundred thousand years ago, we may think simply of the march of the seasons as we know them to-day. Even an ordinary sort of winter means cold, stormy weather, a short daylight, scarcity of fruits and seeds, insects and slugs. For many creatures winter is a pressing problem, which we shall study separately in another chapter, and the neatest solution of all is to migrate. That this was part of the reason for the origin of the migrating custom is almost proved by the occurrence of what we have called "partial migrants"—birds that do not absolutely need to flit, but yet prefer to do so.

There is a third suggestion. The migration at the end of summer may have something to do with the fact that each pair of birds has now a family, and sometimes two families. That means that there are a good many mouths to fill, while the supplies are becoming reduced, not increased. There is often a tendency to overcrowding, and migration is a way out. To sum up then, we can think of birds beginning to migrate because of great changes of climate, because of the difficulty of the winter, and because a little one soon becomes a thousand.

§ 5

An Inherited Drive and Capacity.

Those who study the races of mankind sometimes apply the word "folk-way" to a custom that is handed on from generation to generation without ever becoming a law of the tribe and without being clearly thought out as a wise kind of thing to do. Thus it may be a "folk-way" to drink nothing but milk, or to shift the camp every year about the same time. Perhaps the yearly migrations of birds may be called "bird-ways," but they are continued from generation to generation by heredity rather than by tradition. That is to say, the prompting to migrate and the ability to migrate with considerable success are *inborn* in the bird. Of course birds may use hints that they get from their neighbours, and they may help themselves

Photo: G. C. S. Ingram, M.B.O.U.

LESSER TERN ON NEST.

One of the marks of this attractive bird (*Sterna minuta*), the smallest British tern, is the broad half-moon of white on the forehead. It is one of the terns that actually dive after small fishes and crustaceans, but the complete submersion lasts for a very short time.

by using their keen senses and good brains, but in the main their success in "changing their season in the night" is a gift rather than something gained by experience as successful travellers.

It has been noticed that *caged* birds, made as comfortable as the mistaken kindness of man can devise, sometimes get restless at the migrating time. This means that their whole being is "wound-up" to a regular routine, and it must be kept in mind that the restlessness is shown by birds living alone, that have never known a winter, that never made any journey whatsoever. But that is not denying that birds are sometimes

Photo: Albert Henry Willford.

FEMALE COMMON SNIPE BROODING OUT IN THE OPEN.

The common snipe (*Gallinago gallinago*) is a bird of the moors and marshes, keeping under cover till dusk, then making for soft mud, where it probes for worms and the like. Its nest is a well-concealed grass-lined cup. The photograph shows the long sensitive bill.

influenced by the restlessness of their neighbours, for that seems quite evident. We once brought up black-headed gulls in the laboratory by means of an incubator in order to see what they could do without any help from parents or friends. We were the foster-parent and the young birds got on very well by themselves. They showed, for instance, that they were born with their minds well made up in regard to what was good for them. For we could not get them even to try little pieces of useless stuff like paper or tobacco. To return to migration, however, our point was that when the migrating time came and the young birds were making little flights, they began to take an interest in their kindred who flew overhead across the lawn preparing to leave Aberdeen for milder winter quarters. Our idea is that the sight and hearing of these kinsfolk pulled the trigger of some promptings and memories in the young gulls' brain, for one day they rose from the garden, where they had been very happy, and went off on their great adventure with their kindred.

In one of his poems Matthew Arnold speaks of the restlessness of the tethered stork when he sees his kinsfolk flying overhead in autumn:

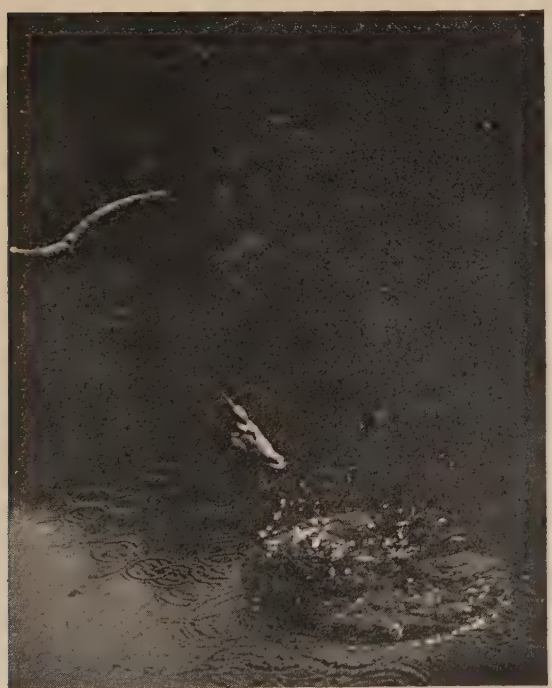
> "And as a stork which idle boys have trapped,
> And tied him in a yard, at autumn sees
> Flocks of his kind pass flying o'er his head
> To warmer lands and coasts that keep the sun,
> He strains to join their flight and from his shed
> Follows them with a long complaining cry."

When a young coot tumbles off the nest into the water it begins at once to swim; the water presses the spring of its inborn capacity for swimming. What may there be in the life of the migratory bird that presses its spring? We have just spoken of the kindred, but the question is why *they* became restless. Part of the answer is perhaps plain when we think of the state of affairs when the summer is over and gone. Food is becoming scarcer, especially seeds and fruits, insects and slugs; the day is becoming shorter, so that there is less time for hunting; there is beginning to be a nip in the air and the weather is unsettled. The more difficult part of the answer is that there are changes within the bird's body which awaken memories—memories older than the individual bird. There are promptings from within as well as spurs from without. In any case we must turn out of doors any idea of the bird looking forward with dread to the hard times of winter, and saying to itself, "It is time to be off." This cannot be the right view, for it is enough to remember that none of these thorough-going summer visitors have ever had any experience of winter. The poet is quite right: they "know no winter in their year." More than that, none of their ancestors ever knew a winter for many thousands of years.

WAYS OF THE KINGFISHER

The kingfisher is one of the most beautiful of birds, and though wandering a little, must be regarded as a typical resident in Britain. It is very well adapted for semi-aquatic life and dives with great skill. Here we see one waiting and watching above a stream on a favourite perch.

The food of the kingfisher consists mainly of aquatic insects, crustacea and small fishes. It dives with considerable splash and the photographer has succeeded in showing the bird at the moment of entering the water in pursuit of a darting minnow.



The movements are carried out with lightning-like rapidity—the entrance into the water, catching of the fish and return to the perch occupy but a few seconds. Often the captured fish is killed by being beaten against a bough.

The kingfisher often shares the catch with his mate, who sometimes answers his signal and meets him half-way, even being fed in mid-air. The parent birds are attentive and painstaking in the training of their young.

After Mortensen.

MIGRATIONS OF THE PINTAIL DUCK (*Dafila acuta*).

The principal breeding-grounds are in Lapland, Finland, and North Russia. Most of the birds were marked at the island of Fano, shown by a spot surrounded by a circle, on the west coast of Denmark. The winter range, shown by the dark circles, extends to the Bay of Biscay, Gibraltar, the Mediterranean, and the Adriatic.

The outside hints that birds receive in autumn are what one might call broad hints, for the conditions of life are becoming uncomfortable. But it is not so easy to be sure what the outside hints are that lead birds to leave their winter quarters to make a long journey to the north. Probably they include the high summer temperature, the drought, and the glare of the sun.

§ 6

How Birds Find their Way.

We cannot shut our eyes to the fact that there is often a thinning of the ranks during the migratory flight. Some birds lose their way in flying across the pathless sea in stormy weather. They become bewildered and exhausted; they sink into the sea and are drowned. We have watched small birds arriving in Cornwall in the spring after a northward flight, and some of them seemed very weary, recalling Tennyson's lines:

"Faint as a climate-changing bird
That flies all night across the dark,
And on the threshold of the land
Sinks to the earth and can no more."

Others are overtaken by very cold weather and perish; some hundreds have been gathered on the streets of a little town. Others are attracted to the lighthouses and dash themselves against the windows, while others still fall under the beaks and talons of the hawks and other captors. All this is true, but the larger fact is that so many of the travellers make the journey successfully. They reach their goal and they return next spring to the north. Can any light be thrown on their way-finding?

No doubt some of them take advantage of coastlines, river-valleys, mountain ranges, and chains of islands. An observer saw a stream of migrant birds passing from the mainland to the nearest island—the first step on their oversea voyage. Yet when a fog came on and hid the island from view, the birds flew along the coast-line. Many years ago we spent a short autumn holiday on Heligoland, and it was interesting to watch the flying squadrons of birds that settled on the island for a rest, sometimes for the night, and continued their journey after a while. One squadron came after another, as if the waves behind impelled the waves before. But we must not think that the way-finding of birds is altogether explained by the birds' ability to use all sorts of landmarks. That cannot be the whole answer, for many birds fly at night and many cross stretches of ocean where there is nothing to be seen even by day.

Even if we suppose—it would not be more than a supposition—that an individual bird could hand on to its offspring the results of its own experience, there would be the difficulty of understanding what the experience would consist of in the case of birds flying by night, at great heights, and across the trackless sea.

There is the same difficulty in regard to the theory that some migratory birds keep up a kind of tradition of successful travelling. Those who followed well for several years might become

good leaders in the course of time. This is an attractive idea, and there may be something in it; but it cannot be the whole truth, for we have noticed already that the young birds usually start for the south before their parents. There is the further difficulty that it is hard to say on what the tradition would be based. We can understand guides on the Alps handing on to their apprentices and sons the secret of difficult climbs. One would say to the other: "When you come to that corner you must climb the face of the cliff for fifty feet," and so forth. Even if they were dumb, the tradition might be established, for the way out of the difficulty could be shown by father to son, mistake. There is some sort of memory of movements, to which these people trust, which is quite different from the painstaking memory of ordinary people who make mental notes of conspicuous buildings and striking shop-signs and peculiar street names. The power of "finding their way home" is also seen in cats, dogs, horses, and cattle; but there is, unfortunately, a good deal of hearsay mixed up with most of the stories.

§ 7

At the mouth of the Gulf of Mexico there is a group of islands called the Tortugas, and one of them, named Bird Key, is the breeding

Photo: Captain C. W. R. Knight.

FLIGHT OF SHELDRAKE.

In ordinary flight the wings begin vertically above the bird's back, and are drawn forwards, downwards, backwards, and up again. Different positions are well shown in the photograph. The common sheld-duck or sheldrake (*Tadorna tadorna*) feeds largely on "shellfish," to which its English name probably refers. It often uses a rabbit's burrow as a nest.

generation after generation. But in the case of birds migrating, as some of them do, at night, at a great height, and across the sea, what would there be upon which to base the tradition?

So we do not see what can be done at present except to fall back on the interesting old view that birds have in a high degree what many animals have in a small way—*a sense of direction*. There are men who can walk from the railway station into the heart of a great city they never visited before, and then after an hour of winding streets and many corners turn on their heel and go back to the station. In some way, which cannot be easily explained, they register in their nervous system the broad features of their walk from the station, and they return without

The Story of the Homing Terns.

place of two southern terns—the noddy tern and the sooty tern, which do not go further north.

Two students of animal behaviour, Professor J. B. Watson and Dr. K. J. Lashley, resolved to experiment with the terns to find out what they could do in the way of "homing." At the nesting time they caught strong, vigorous birds and marked them with labels and a little oil-paint, marking the nest with the same number and date. The tern was then put into a large hooded cage, taken on board ship, and then liberated at some selected spot. The birds were not allowed to see anything, but they were, of course, well looked after. They got plenty of minnows from the refrigerator.

Very remarkable results followed. From Galveston, the capital of Texas, 800 miles from Bird Key, some of the terns returned. The time they took varied greatly; some took six days, others twelve. Three sooties taken to the island called Key West, only 65 miles off, returned in 3 hours, 45 minutes, but they probably spent part of that time on the feeding ground before reporting themselves at their nests. From some journeys of over 500 miles some terns returned in 3–5 days, but the time they took must not be regarded as indicating the rate of flight.

Two noddies and two sooties were taken in the stateroom of a steamer to Havana and liberated in the harbour there early in the morning of 11th July. Next day they were back at Bird Key. This was a journey of 108 miles, but a large part of the time was probably spent off the shores of Cuba. Of five birds liberated off Cape Hatteras, which is half-way to New York, at least three returned in a few days, having accomplished a journey of 850 miles "as the crow flies," and much more if they followed the alongshore route. Here it must be remembered that these northern waters were altogether new to the birds, for the Tortugas mark the limit of their ordinary range.

Four noddies and four sooties were taken in a hooded cage on a Galveston steamer to about 461 miles from the nesting island, and liberated where no shore line was visible. The vessel was steaming westwards, of course, but when the eight birds were liberated all but one started east. That one headed west and continued for about 200 yards, then turned suddenly and flew eastwards like the others. They had a strong head wind against them throughout the first day, but two of the noddies returned in safety to Bird Key. Sometimes they were not so successful. On 4th June, eleven birds were set free in Galveston Harbour, 800 miles from home; on 9th June one of the observers, travelling on the steamer to Bird Key, saw one of his terns (a red-marked sooty) resting upon a piece of driftwood in the open sea more than half-way home—about 409 statute miles east of Galveston. Unfortunately the setting in of stormy weather prevented a successful return.

After Mortensen.

THE MIGRATION OF THE WHITE STORK, AS SHOWN BY RINGING RECORDS.

The principal winter quarters of storks from Europe are in Africa, from the headwaters of the Nile south to the Transvaal, Orange Free State and Cape Colony.

What these experiments clearly prove is that nesting birds, with some inducement to return, can find their way home from a distance of 800 miles or more across seas or along coasts unknown to them, and without having had any vision of where they were travelling on the outgoing voyage. The observations are very satisfactory, but they do not throw any light on the problem of where the sense of direction has its seat.

It is evident that the way-finding power exhibited by migratory birds remains in great part a puzzle. We do not really understand how they find their way so successfully to an unknown goal—namely, their winter quarters in a southern country which is to the young birds a *terra incognita* indeed. Nor do we understand their return the following year to their summer quarters, even in some cases to their particular birthplace. In face of such puzzles it is useful to consider somewhat similar facts, such as the power some human beings and some mammals have of finding their way home, often over difficult country. It is possible that some light on

Specially drawn for this work] [*by Richard Ogle.*

SALMON GOING UP-STREAM TO SPAWN.

It is a thrilling sight—oftenest to be seen in Autumn—when the salmon leap waterfalls on their way up-stream in search of suitable gravel-beds on which to spawn. Six or seven feet is a not uncommon leap, and a large male salmon has been known to jump as much as ten feet. This is an extraordinary gymnastic triumph.

ordinary migration will be found in a careful study of homing pigeons, but their remarkable accomplishments are largely the result of careful selective breeding and of patient individual training. To begin with, they are educated for short distances, in the same direction from home. Those birds that prove themselves "non-educable," often a large percentage, are soon relieved from further tuition, but the good learners can find their way home from a distance of 200 miles before they are a year old. A full-grown carrier pigeon can often return from 500 miles, and there are some much more striking records. Thus there was one that flew 634 miles in one day of eighteen and a quarter hours, and another (in America) that covered 1,010 miles in thirty-five and a half hours, including night stoppage. A noteworthy fact is that the carriers take disproportionately longer when the distance is much increased. Thus a week may be spent over a two days' distance. This suggests that there is considerable searching about for landmarks, and that keen vision and topographical memory contribute greatly to success in homing. This is corroborated by the fact that the pigeons do not fly by night, and that they are in varying degrees bewildered by fog. When they are liberated they usually ascend to a great height and describe a circle, as if they were taking their bearings. It must be noted that there are many failures, as well as geniuses. In a famous Rome to Derby flight of a thousand miles or so we believe that only two carriers, out of 106, succeeded in finding their way home, and one of these took twenty-three days. This strongly suggests that many tentative flights were made in various directions before remembered landmarks were reached.

Photo: Captain C. W. R. Knight.

HAWK CHASING MIGRANT BIRD.

The risks run by birds on their migratory journeys are many. Stormy weather may lead to over-fatigue and fogs to bewilderment; and there is always the danger of being overtaken by watchful birds of prey.

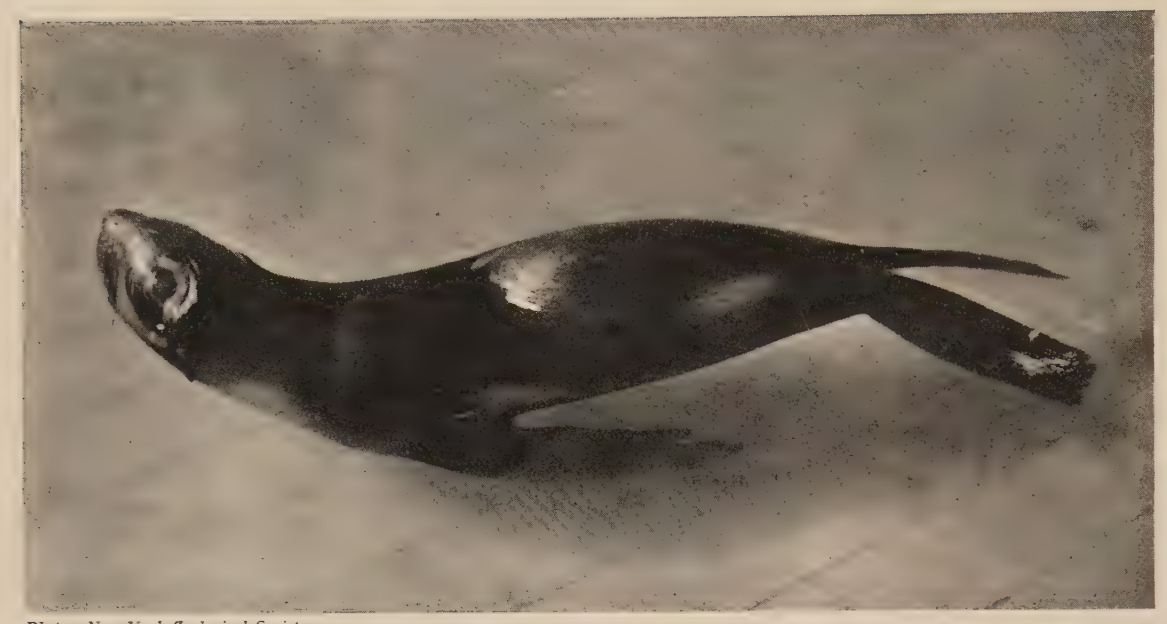


Photo : New York Zoological Society.

ALASKAN FUR SEAL.

This northern seal (*Callorhinus alascanus*) breeds (under protection) on the Pribilof Islands in Alaska and on other islands off Kamchatka. It used to have other breeding-grounds, and occurred in larger numbers. But it has been restricted and reduced by greedy hunting, now under control. It migrates southwards in winter as far as California.

XVII
ANIMAL JOURNEYS

THERE are several kinds of mass-movements among animals, and the name Migration is often loosely applied to any of them. The word migration does not really mean more than passing from one place or country to another, but it has come to be applied to a particular kind of mass-movement, and it will make for clearness to keep it strictly to that sense. Migration in the strict sense is that seasonal change from summer quarters, where the young are born and brought up, to winter quarters, where adults and young alike feed and rest in preparation for the journey back to the breeding-grounds, and the strenuous labours that await them there. True migration is therefore bound up with weather, with food supply, and, perhaps mainly, with the birth of the young. In this sense it is best illustrated among birds, but many other animals migrate regularly every year.

§ 1

The Alaskan Fur Seal.

The fur seals of the Northern Pacific spend almost two-thirds of the year in the open sea, the large males, or bulls, keeping apart from the troops of females and young immature males. They follow the fishes, and especially the cuttlefishes or squids, which form their favourite food. They may be seen far out at sea tumbling and playing on the surface of the water, just as dolphins do, and during all that time they never come near the land. When spring comes, however, they set out for their breeding places, and " many of them travel steadily across more than two thousand miles of the North Pacific. For days at a time they swim through a roaring, gale-swept sea, under dense, low-hanging clouds, and with unerring certainty strike certain passages in the Aleutian Islands, through which they travel to their breeding-grounds, more than

a hundred miles beyond, on the small fog-hidden Pribilof Islands."

Early in May the bulls begin to arrive at the shores of the islands. The bulls are large, fat, and in splendid condition, and they land on the beaches, where each chooses out a special territory several yards square for himself, and prepares to defend it against all comers. The favourite sites are those nearest the water, and these usually fall to the largest and strongest bulls. A great deal of fighting goes on, and no bull leaves his territory for a moment, so that for many weeks they neither eat nor drink, and they get very little chance to sleep!

The gentle cow-seals, which are only about a fifth of the size of their partners, arrive about a month later. They get rather a rough welcome, for each bull wants to get as many cows for himself as he can, and though he proceeds by coaxing and enticing, there is such constant quarrelling with other males that the females do not have a very peaceful time either. Even when one is quietly settled down, a neighbouring bull may seize her and carry her off by the scruff of the neck to his own ground, while her original lord and master is engaged in trying to coax another new-comer to join his household. The seals remain on the islands for at least four months. After the first few weeks the cows go regularly to the water to fish, and as the fishes they like become scarce about the coasts they have to make longer and longer excursions. The young seals, too, go down to the sea in swarms to play and to learn to swim and catch fish, but each mother can invariably pick out her own calf from many hundreds, and she repulses all others.

Photo: Herbert G. Ponting, F.R.G.S.] [*Reproduced from "The Great White South."*

WEDDELL SEALS RESTING ON PANCAKE ICE.

This large Antarctic seal (*Leptonychotes weddelli*) feeds mainly on cuttlefishes. Large numbers are sometimes seen sleeping on the beach after a heavy meal. The mothers always pup on the ice-floe near to land. The pups are two to three feet long at birth.

Towards autumn the great colony begins to break up, the big bulls being the first to go. As it is only during the three or four weeks just before leaving, if even then, that they have had any food or rest, they are thin, exhausted, and not nearly so pugnacious as when they arrived. But they soon pick up again in the quieter conditions, and with the abundant food of the open sea.

During mild winters it is said that the seals never go very far from the shores of their island home, for the place where an animal brings forth its young is its true home, and is often, though not always, the original home of its race. But in severer winters the cows and young males may go as far south as off the shores of California, though the bulls usually remain about the coasts of Alaska.

§ 2

Turtles and Sea-Snakes.

The large fish-eating turtles live in the sea except for a short period every year, when they return to land to lay their eggs. This is also true of seaweed-eating edible turtles, which keep to inshore waters. In neither case do the turtles stay long, for they bury their eggs in the sand and leave them to be hatched by the heat of the sun. When the young turtles emerge they make straight for the sea, and are immediately able to fend for themselves. Turtles were originally land reptiles that changed their habits and took to sea-life, but their young must be born on the land, from which their race originally came. For though the whole habits of life have changed, the turtles still lay hard-shelled eggs, which would be immediately lost in the sea.

Some sea-snakes, too, come to the rocks to bring forth their young, and they stay with them for a little while. The young are born alive, and as they are lung-breathers, like land animals, there would be great danger of drowning if they were born in the water. After a little practice they learn to keep their nostrils shut under water and to come to the surface for gulps of air.

§ 3

The Salmon.

Among fishes there are many good examples of true migration. Salmon live and feed in the sea from the time they are about three years old; but when they are impelled by the desire to breed they enter the rivers and press steadily upwards, turned aside by no obstacle they can possibly surmount. They can leap a waterfall ten feet high, and can overcome strong rapids. When they reach a suitable bed of gravel the female

Photo: James's Press Agency.

A LARGE GREAVED TORTOISE.

This Sudanese tortoise (*Testudo calcarata*) is a good example of the terrestrial Chelonians. Boxed in above and boxed in below, with retractile head and tail, and limbs, they are practically invulnerable, and the strength of their arched carapace is extraordinary. But most of them pay for their extreme perfection of armour by having great sluggishness of life-processes.

Photo: Underwood Press Service.

GIANT TORTOISES.

Gigantic land-tortoises belong to the same genus (Testudo) as the small Greek tortoise. They have been known to reach a straight length of over a yard. They are now much reduced in numbers and restricted to the Galapagos Islands and some islands in the western Indian Ocean.

makes writhing movements and lashes with her tail, thus hollowing out a furrow in which she deposits some of the eggs. The waiting male follows her, and sheds his milt upon the eggs, and the female then covers the furrow with gravel by a similar lashing movement of her tail. Both fish move slowly upstream and repeat the same process till all the eggs are laid. The spawning-bed of a single pair may cover five or six feet of ground. The male takes no part in making or covering the bed, but he fiercely drives off rivals and intruders. When the work is over the female retires, utterly exhausted, to a deep pool to rest, and the male follows a little later. But the mortality among the males is great, and many of them do not survive to return to the sea.

Spawning takes place between October and January, but the adult fish do not go back to the sea till spring, so the greater part of a year is spent in fresh water. From the sea some may return in a year, but many let two, three, or even four years pass before ascending the river to spawn again.

The newly hatched fish, known as alevins, are burdened with heavy yolk-sacs, which are sufficient to supply them with food for about six weeks, during which they lie very quietly at the bottom of their pool. Then the " fry " begin to feed, and they grow into trout-like " parr," which are very active in the river for a couple of years or so. Early in their third year they become silvery " smolts," and go down to the sea. They have had many enemies all along, but the journey to the sea is perhaps the most dangerous time of all. Cod and other fishes are said to lie in wait for them at the river mouths, while gulls and cormorants pick them up in scores out of the estuaries. But those that reach the greater safety of the sea feed and grow very rapidly. Some of them may return as " grilse," not yet showing the colouring and characters of the adult, and they may spawn at that stage ; but many remain one or two years, or even longer, in the sea, and only come up the river as mature salmon.

How do we know all this, since it is not possible to follow the fish on their journeys from fresh water to salt, and from salt waters back to fresh waters ?

There are three chief ways in which this knowledge has been gained. (1) Much light was

Photo: New York Zoological Society.

SEA-SNAKE.

Sea-snakes (Hydrophinæ) range from the Persian Gulf to Central America. They are poisonous and fish-eaters. The tail is flattened in adaptation to swimming and there are no enlarged ventral scales. The young are born on the shore. About fifty different kinds are known.

thrown on the salt-water phase by observing the smolts continually on their way to the sea, and then fishing for them throughout the whole year, so as to note what food-fishes they followed, and what size they were at different seasons.

(2) Some fish were marked by fastening a piece of silver wire with a numbered plate attached, to the base of one of the fins. It was found that the fish thus marked nearly always came back to the same river, thus the length of their stay in the sea could be reckoned.

But most interesting and fruitful of all is the third method, that of reading the history of the fish as it is written on its scales. For the scales go on growing throughout the lifetime of the salmon, not evenly and regularly, but at a rate corresponding to the conditions of food supply and temperature. Thus in winter the growing scale forms circular ridges that are very close together, while in summer, when food is abundant, the rings are further apart. When the salmon go up the river to spawn, growth ceases for the time, and the edges of the scale become worn and ragged. When growth begins again and the next ring is formed, this "spawning-mark" remains visible. Thus a trained observer is able to read from a scale under the microscope how many winters the salmon has lived and how many summers, and also how many times, and at what intervals, it has spawned.

The Sea-Lamprey.

The large sea-lamprey comes up the river to breed just as the salmon does, but with this difference, that the parent lampreys never recover from their exhaustion, but die soon after spawning. The eggs are safely laid, however; the young emerge, feed, grow, and in due time go down to the sea, so the race is carried on.

The story of the eel and its wanderings is so complicated and fascinating that it has a chapter all to itself.

The land-crabs of Jamaica and the Pacific Islands are a good illustration of the same type of mass-movement, but their story is told in another chapter.

§ 4

Let us turn now to movements which are not migratory in the strict sense, because they have no direct connection with breeding. They may be called periodic wanderings. These may be due to conditions of weather, or of food-supply, or both, for the food-supply is often a matter of the season. Thus shoals of herring and mackerel are continually moving about from one part of the sea to another, following in the wake of the small animals on which they feed, and they are followed by larger fishes and other animals, which prey upon them in their turn.

Periodic Wanderings.

Mr. Lockwood Kipling tells us that when the figs in the groves round the temples in India are ripe, the monkeys come forth in troops from the jungle to feast upon them. The figs have indeed been planted for the monkeys, which are held sacred in India, but unfortunately they do not confine themselves to the fruit intended for them, but rob every field and garden on their way. And in South America we are told, "whenever the golden orange glows among the dark foliage of the plantations, the capuchin monkey makes its appearance to share the fruit with the owners."

Monkeys.

On the steppes and uplands of Asia, the wild ass lives a free and joyous life. "The range of the mountains is his pasture, and he searcheth out every green thing." The asses form small troops, consisting of a male, several females, and some foals. Like the domestic ass, they are easily satisfied

Wild Asses.

Photo: F. W. Bond.

ASIATIC WILD ASS OR ONAGER.

The onager (*Equus onager*) is the best known of the wild asses, which differ from horses in tail and mane and other superficial features. It is a sandy-coloured animal, with a dark median stripe. Famous for its swiftness, it is found in Persia, the Punjab, and the country of Cutch.

in the matter of food, and live quite happily on dry and rather salt herbage. But when winter comes even that begins to fail them, and troop joins troop till a vast army is formed, and they begin to march *northward*. It is not warmth they are in search of, but snow, for wherever the ground is covered they can get grass enough for their needs by scraping the snow away with their hoofs. But when a thaw melts the surface of the snow, and is succeeded by a frost severe enough to turn it into a cake of solid ice, the wild asses are in sore straits and many of them perish.

In southern countries, such as South Africa, it is the long dry season which makes life difficult for grass-eating animals. It is then that antelopes, gazelles, and all sorts of herbivores stampede in thousands from the thirsty land.

§ 5

In addition to regular seasonal mass-movements, there may be a sudden irregular dispersal of animals on an even larger scale. This may be due to some change in physical conditions, or to a great increase in the numbers of some particular kind of animal on a particular area.

Irregular Dispersals.

On the plains of the Argentine it is sometimes observed that dragonflies are flying in one direction in such immense swarms that the air is darkened with them. When this happens the dwellers on the plains shut up their houses and bring their stock under cover, for they have learnt that, in some way not understood, the dragonflies are able to sense the coming of the dreaded wind-storm—the pampero—fully a quarter of an hour before it can be detected by human beings. When the storm actually breaks, the insects alight, crawl into every crevice and under every leaf that can afford shelter, and remain cowering there till it has subsided.

Dragonflies.

Among the small rodents, which all have big appetites, and multiply very rapidly, we find many examples of this kind of irregular forced migration. Let us take the lemmings as a striking illustration.

§ 6

All over the northern parts of Europe, Asia, and America lemmings are abundant at all times. There are several species of them, but, with the exception of the banded lemming of North America, which alone turns white in winter, they are so like each other that they may all be taken together. They are very like many of the common field mice in appearance, but are larger and rather dumpy-looking, their tails are shorter, and the hair on their backs is very long. They are brownish in colour on the whole, but they vary greatly. They keep chiefly to the opener parts of their region, and live in burrows, which have more than one doorway. In these burrows they bring forth their young. There may be as many as eight in a litter, and there is more than one litter in a summer.

The Story of the Lemmings.

They are very active; they are said to be about in search of food both by day and by night, and they do not sleep or even remain in their burrows through the winter, as so many other rodents do. So it is easy to understand that they require a great deal of food, and that a very good season, when abundance has caused multiplication to be even more rapid than usual, may be followed by a period of famine. Whenever scarcity threatens the lemmings grow restless. They pour forth in streams from every part of the hillsides and the tundras, and gather together literally in millions. Soon they begin their hunger-trek, instinctively moving directly northwards. At first they are orderly enough; they feed as they go, and when such a horde has passed over a cultivated patch not a living blade is left. They come to the banks of a stream, and they may be seen running up and down searching for a safe place to cross. But as time goes on they become panic-stricken and desperate. Their march is now a headlong flight, and if a broad river stretches across their path they throw themselves in and swim to the other side—those who can. Those that get safely across press on more wildly than ever.

All the time a heavy toll is taken by what one naturalist calls the "funeral procession" which follows them—owls and hawks, lynxes, foxes, and weasels. Disease thins them, too, the weakly ones fall out, and many of them get killed in strange ways. In the autumn of 1923, for instance, it was reported that lemmings were passing along the highways of Norway, and that great numbers of them were killed by

Specially drawn for this work] [*by Roland Green, F.Z.S.*

THE ALBATROSS

Of all kinds of flight, "sailing" is the most marvellous. The albatross circles round the ship, both with and against the wind, and for long periods there are no visible wing-strokes

motor cars. Many of those that reach the shores of the North Sea throw themselves in and swim, but they quickly perish.

Not all the lemmings, however, come to such a tragic end. Some of them make good, and find new fields; some of those that dropped out recover from their exhaustion, and in a very few years the little lemmings are abundant again over all the northern plains. It is the old story: the individuals may perish in millions, but Nature takes care that the race is safe.

Photo: American Colony, Jerusalem.

THE DREADED LOCUST, WITH FOLDED WINGS.

Locust is a general name for hundreds of insects allied to grasshoppers. As the photograph shows, the hind-legs are very muscular and suited for hopping and scrambling.

Locusts

Very well known are the wanderings of the locusts. They move to some extent every year, but occasionally—it is said to be once in eleven years on an average in America—there is a great increase in their numbers. Then swarm unites with swarm and they begin to move, leaving desolation in their track. The swarms of young locusts, which may begin to wander on foot within the first few days of life, are hardly less dreaded than those of the winged adults. Fortunately they have many enemies, for man alone could never cope with them. Canon Tristram tells us that he once saw such a horde reach a belt of trees on the banks of the Jordan. They climbed the trees, ate off every green leaf, and then fell into the river below. "But the river was full of fish patiently waiting for the feast, which continued for hours dropping into their mouths."

The movements of the so-called "army worms" have often excited great astonishment. These are the maggots of a fly, and they hatch out in damp woods among rotting vegetable remains. There they feed and grow, but if very dry weather sets in and the floor of the wood ceases to be damp, the army worms must march. Different companies meet and combine into battalions, these into regiments, and these into armies, sometimes ten feet long, and six inches across—an extraordinary instance of the abundance of life. In most cases the maggot army comes to naught—the birds see to that.

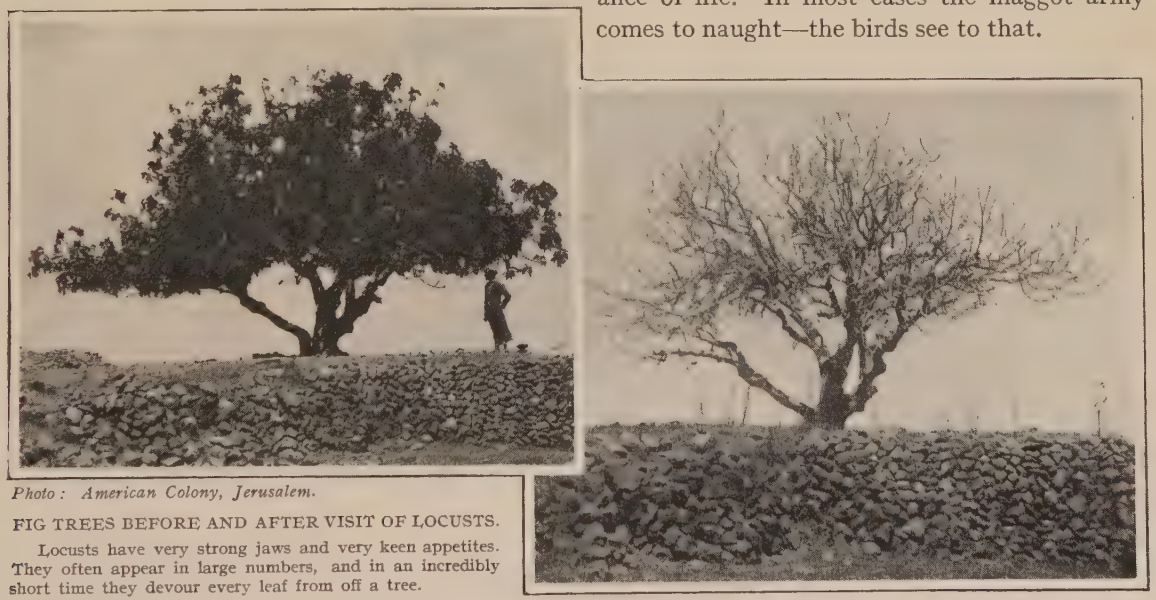


Photo: American Colony, Jerusalem.

FIG TREES BEFORE AND AFTER VISIT OF LOCUSTS.

Locusts have very strong jaws and very keen appetites. They often appear in large numbers, and in an incredibly short time they devour every leaf from off a tree.

Looking backwards, then, we see that there are (*a*) true migrations, as in fur-seals, birds, marine turtles, and salmon; (*b*) regular big movements, which occur in connection with seasonal changes, as in the cases of wild asses; and (*c*) irregular wanderings due to a flood in the river of life; that is, to an enormous increase in the number of mouths to be filled, as in the case of lemmings and locusts.

XVIII
LIFE IN MOTION

THE grandest movements in the world are those of the "stars in their courses," of the planets in their elliptical orbits, and of vast systems, like the Solar System, drifting through space to unknown goals. But there is a true sense in which the flight of the swallow is more wonderful than any of these; for the swallow commands its course and changes it, as we say, "at will." In any case, the swallow moves in accordance with laws far more complex than those that serve to describe the movements of the earth. If we light up one end of an aquarium more than another, we can prophesy, from previous knowledge, that in a short time certain animals will be at the light end and others at the darker end. But in regard to higher animals, like birds and mammals, it is very difficult to lay down rules about their movements. As we say, No one can tell how the cat will jump!

Four great kinds of Animal Locomotion.

Professor F. W. Gamble, of Birmingham, gives in his very delightful and stimulating book on "Animal Life" an account of the four great kinds of animal locomotion. It is so clear that we are bound to use it. He asks us to think of the alternatives open to a man in a boat provided with oars, a pole, and a boat-hook. What can the man do?

(1) First of all, the man in the boat may haul with the boat-hook, fixing it to the sides of the stream or to the crooked knees of alders on the bank. Now this is what the leech does when it fixes its muscular mouth and hauls itself forward, and it is by hauling that the starfish climbs up the rock.

Photo: John J. Ward, F.E.S.

WATER BOATMAN (*Notonecta glauca*).

This common water-bug can swim and dive to perfection; but it is also able to fly by means of two delicate wings, usually hidden away under wing-covers or elytra.

(2) The man in the boat may try a second method. He may scull from the stern of the boat with a single oar, displacing masses of water first to one side and then to the other. It is in this way that a whale swims, by using the horizontally flattened flukes of its tail, churning the water from side to side. Its tail has been transformed into a propeller, but it is a propeller that does not turn round.

(3) Thirdly, the man may punt with the pole pressed against the floor of the stream or pond. Of course, he could use one of the oars for this purpose, but it would not improve the oar.

Photo: John J. Ward, F.E.S.

ROWING LEG OF WATER BOATMAN (MAGNIFIED). *Inset:* INSECT'S NATURAL SIZE.

The water boatman is one of the water-bugs (*Rhynchota*). It is common in ponds, and is so light that it seems to find it difficult to keep away from the surface. The name Notonecta means back-swimmer, and it is on its back that the water boatman rows quickly about. Its oars are the third pair of legs, and their stroke is helped by the numerous hairs which are so well shown on the photograph. The boatman feeds on small water animals.

The punting kind of locomotion, only in more complicated form, is illustrated when we walk across the room or when a beetle runs along the road. There is a pressing of a lever against a hard fulcrum—the substratum.

(4) Finally, the man in the boat may sit down and row with the two oars, displacing masses of water on the two sides simultaneously. When a turtle is swimming in the sea it does the same, rowing with its fore paddles. The pond-insect called the Water Boatman (Notonecta) swims with its keeled back downwards, rowing by means of its third pair of legs, which bear towards the end a fringe of stiff bristles, greatly increasing their oar-like quality. But in the evening the Water Boatman sometimes flies about with a whirr, thus illustrating another kind of locomotion. Yet it is after all the same kind, for flying is in a general way rowing in the air with the wings for oars. The penguin is a flightless bird that swims in the sea, using as oars both its flipper-like wings and its feet. But an ordinary flying bird may be broadly described as *rowing* in the air. In the next chapter we shall see that it is somewhat peculiar rowing.

In almost all animals the movements are due to contractile muscle-cells, usually compacted into groups, which are called muscles. A piece of ordinary flesh is a piece of muscle. But the simplest animals, being unicellular, have no muscle cells, and there are some multicellular animals which move mainly by means of living lashes or cilia, though they have muscle-cells besides.

Movement without Muscle.

Among the simple animals are the Amœbæ, which flow along the surface of solid objects in pools and ponds. A few live in damp earth and others live as parasites in man and animals. The Amœba's movements are very puzzling. They are not "anyhow" movements, for it often moves directly towards something attractive or away from something disagreeable; and when it is simply exploring, it moves in a loose spiral, like a corkscrew greatly elongated. A spiral course in swimming is illustrated by many animals and also by a swimmer who is blindfolded. When the gliding Amœba is carefully studied under the microscope, it shows particles on the upper surface disappearing over the

Amœbæ.

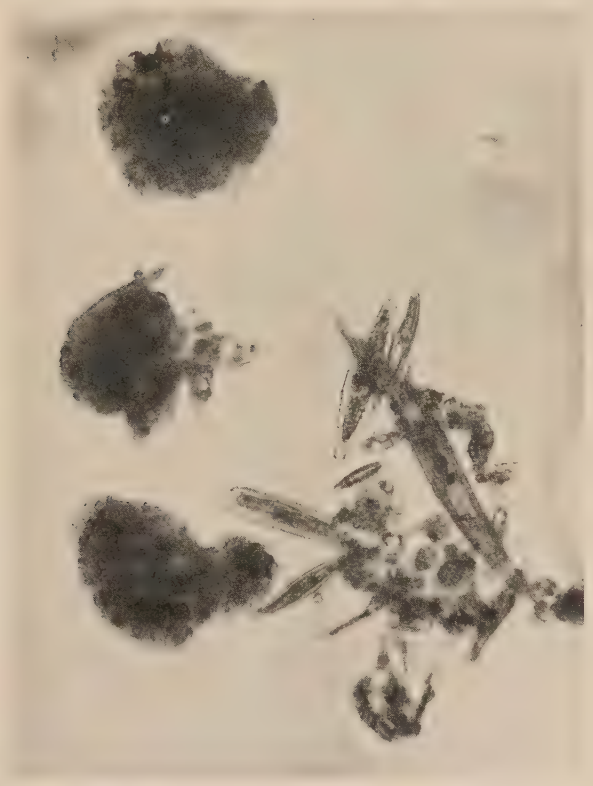


Photo: John J. Ward, F.E.S.

AMŒBÆ FEEDING ON DIATOMS (MAGNIFIED).

The dark irregular bodies seen in the photograph are amœbæ, which are among the simplest of animals. A common size is about 1/100th of an inch in diameter. The spindle-shaped bodies are diatoms, among the simplest of plants.

front end, and after a short time reappearing behind, to begin once more a forward journey. It looks like a caterpillar-wheel mode of movement, and it would be very interesting if the Amœba, flowing along or "rolling along," was a primæval anticipation of the "tank." Its rate per minute is often 600 microns; a micron is a thousandth of a millimetre. There seems to be a mobile surface layer in the Amœba, and in the deeper zones of the living matter there is an active streaming of microscopic particles, such as may be seen in our white blood corpuscles, which exhibit "amœboid" movements. There seems no doubt that what is called "surface tension" plays an important part in the Amœba's movements; but we must confess that even after reading Professor Asa A. Schaeffer's monograph on "Amœboid Movement" (1920) we do not understand how the Amœba moves along the surface of a stone in the pond.

In contrast to the Amœba's slow gliding there is the rapid movement of Infusorians by means of living lashes, which are called cilia or flagella. An Infusorian may have a single flagellum, which undulates in the water like a serpent and pulls the animalcule after it; or there may be two or three flagella. In other cases there are hundreds of cilia, which are alternately bent and straightened—a very pretty sight to watch under a high magnification. We have *stationary* ciliated cells in our wind-pipe and bronchial tubes, which by their continual lashing help to keep the air-passages clear.

Ciliated Animals.

There are very beautiful Open-Sea animals called sea-gooseberries or comb-bearers (Ctenophores), which move by means of eight meridians of ciliated combs. Each comb is formed by the fusion of a number of ciliated cells in a row. These transparent luminescent Ctenophores capture small animals, such as Crustaceans and larval fishes, in the open sea, and they are quick to save their delicate bodies by descending below the surface whenever there is the beginning of a storm.

When we peer into a shore-pool and do not expect to see everything in the first five minutes, we may sometimes detect a small leaf-like animal gliding along the surface of a stone or seaweed. It is a Planarian or Turbellarian worm, moving by cilia on the under-surface.

Planarian Worms.

Many Planarians are about the size of a finger-nail, and the way in which they glide along has earned for them the name of "living films." Their movement is all the more attractive because we cannot see how it is effected, the locomotor cilia being quite microscopic. They beat backwards against a thin layer of slime, which the worm secretes as it goes, and so far as we know the movement is always head foremost. The rate may be a hundredth of an inch in a second. Other Planarians are seen gliding more slowly along the under-side of the surface-film of a fresh-water pool, or rowing with their cilia on the surface of a fresh-water plant. Others, again, are at home in damp earth. It is interesting to notice that the Planarians were perhaps the first many-celled animals to have right and left sides, and to move consistently head foremost.

Photo: F. Dobson, F.E.S.

FROG SWIMMING—COMMENCEMENT OF STROKE.

The frog moves both fore-limbs and hind-limbs when swimming, but most of the work is done by the latter. They are jerked backwards until the feet touch.

They are the simplest animals with head-brains, and we may look back to them as the beginners of that line of progress which has led to man's knowing his right hand from his left. Another point of interest is that the Planarians can survive being cut into several pieces. A head cut off re-grows a posterior end, and an excised posterior end re-grows the head. If a whole be cut into four pieces the result, after a time, is the formation of four whole worms. They seem to be almost immortal. To avoid misunderstanding we may mention that while Planarians move by the lashing of their cilia, they have also muscle cells, by means of which they can bend their body.

Young Oysters.

Locomotion by means of cilia is illustrated by a great many juvenile stages of animals which move by muscles when fully formed. Thus the larvæ of starfishes and sea-urchins, of marine ringed worms and many molluscs, swim about by means of cilia. No adult animal is more sluggish than the oyster as regards locomotion, but the newly hatched oyster is a vigorous free-swimmer. If a flat glass vessel be filled with surface-water from an oyster-bed about midsummer, one is likely to see—just vaguely with the naked eye—a dancing movement of larval oysters. Each is about $\frac{1}{150}$th of an inch in length and almost transparent. Its lively movement is due to a propeller of long cilia at one end, just in front of the mouth, and this reminds one forcibly of the ciliated organ on the head-end of the wheel-animalcules or Rotifers, beautiful minute animals very common in fresh water.

After a short time of free-swimming the young oyster settles down on a stone or shell. It is then about one-twentieth of an inch in diameter. It settles down for the rest of its life, but its ciliary activity continues on the skin and gills. It may be mentioned that one of the easiest ways of getting a good impression of the action of cilia is to cut off a small piece of an oyster's "beard" and examine it in water under the microscope.

Even among backboned animals there is a lingering presence of superficial cilia in the larval stages, but the highest level at which this occurs

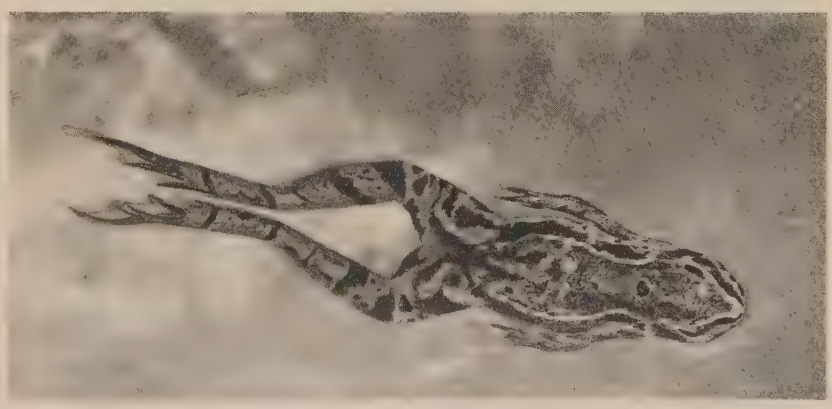


Photo: F. Dobson, F.E.S.

FINISH OF DOUBLE-STROKE.

The fingers are free, the toes are at least half-webbed. The whole hind-leg is as long as the rest of the body, and an elongation of the ankle region greatly increases the stroke-surface.

is among Amphibians. The newly hatched tadpole, as we shall afterwards see, is covered over with ciliated cells.

In the section on the ways of shore-animals a description was given of the way in which a starfish opens a mussel. The question now is how the starfish creeps up a rock. In the groove on the under-surface of each arm of the common starfish (*Asterias rubens*), there are several rows of soft suckers or tube-feet, which are connected with little muscular bladders (ampullæ) inside the arm, and with a water-vessel that runs along, supplying both the bladders and the tube-feet. This is part of an elaborate hydraulic system called the water-vascular system, which is confined to starfishes, sea-urchins, and their relatives. The water enters the system by a remarkable plate on the dorsal surface between two of the arms. It is perforated by minute pores like the "rose" of a watering-can, and is called the madreporic plate. The water passes through it into a limy twisted tube called the stone-canal, which is like an elaborate filter inside. This leads into a water-ring round the mouth, whence the water passes by a radial vessel to the bladders and tube-feet. As this is rather complicated, it may be written down like this:

Hauling Methods of Locomotion. The Starfish.

DORSAL ENTRANCE PLATE (MADREPORIC)
↓
TWISTED SUPPLY CANAL (STONE-CANAL)
↓
WATER-RING AROUND MOUTH (CIRCUM-ORAL)
↓
RADIAL WATER VESSEL (ALONG THE ARM)
→ INTERNAL BLADDERS
↕
→ EXTERNAL TUBE-FEET

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

LIVING STARFISH, SHOWING THE UNDER SURFACE, WITH THE CENTRAL MOUTH AND THE TUBE-FEET IN ROWS.

The tube-feet are soft finger-like outgrowths in the groove on the ventral surface of each arm. They can be made to adhere to the rock, and then the contraction of their muscles pulls the starfish along.

The tube-feet are filled with water and become tense, like a hose-pipe when water flows into it at considerable pressure. They are pressed like fingers against the rock. A back-flow of water occurs from the tube-feet, with the result that a partial vacuum is formed between the closed tip of each tube-foot and the surface of the rock.

The tip of the tube-foot adheres firmly, like the schoolboy's leather sucker on the street pavement. Thus the starfish is firmly fastened to the rock, and the next step is to contract the muscles of the attached tube-feet. As the tube-feet shorten they draw the starfish upwards, just as the ship is drawn close to the pier by winding in the hawser. By the shortening of the tube-feet the starfish is *hauled* up towards the place of attachment. Then there is an energetic contraction of the walls of the bladders, which

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

STARFISH CRAWLING ON SAND.

When the starfish is climbing up a rock or on a hard surface it moves by means of its numerous tube-feet—a hydraulic locomotor system. The tube-feet are fastened and then shortened, so that the animal is pulled upwards or onwards. But when the starfish has to move on soft sand it depends partly on levering its arms against the rough surface, thus wriggling along.

recall elastic syringes, and as each tube-foot has its bladder there is an obliteration of all the partial vacua. The tube-feet are thus loosened and are ready to repeat the process further up. The starfish would slip down when the tube-feet are loosened, were it not that another attachment has meanwhile been effected by another set of tube-feet. They work in relays, alternately fixed and loosened. All this takes a long time to describe, but the starfish climbs up the rock—at more than a snail's pace!

The movements of a medicinal leech on a solid object, such as a stone or the wall of the aquarium, illustrate very clearly locomotion by hauling. The leech has a large posterior sucker, used for adhesion only, while the anterior sucker has the mouth in its centre and fixes the animal when it is gorging itself with blood. Let us start with a leech that has fastened its posterior sucker, which adheres firmly because a partial vacuum has been made between it and the substratum. This vacuum-making is due to the contraction of the muscular walls of the sucker, which do what the string does in the street-boy's leather disc when he pulls up the string. The leech elongates itself by contracting the circular muscles that run round the body like the hoops of a barrel, and the anterior part becomes very narrow and tapering. It seems to be searching for something to fix on to, and when it finds it the mouth sucker is fastened. The next step is to loosen the posterior sucker, and then the leech draws its body forward by contracting the longitudinal muscles that run like the staves of a barrel. But they are more contracted below than above, so that the body is arched up like a horseshoe. When the posterior sucker reaches the anterior sucker, the two are close together for a brief moment. Then the anterior sucker is loosened and the body reaches forward again. So we come back to where we started. It takes a long time to describe, but the leech moves at a good pace. The same sort of looping movement is exhibited by "looper" caterpillars, and at times by the fresh-water Hydra.

Photo: John J. Ward, F.E.S.

BROWN LIZARD ON A ROCK.

The lizard often uses its tail as a lever when climbing, and as a brake when descending. The scales covering the surface give it a considerable gripping power. If the tail is caught, a reflex breakage may occur right through the middle of a vertebra, and through the muscles. Thus the creature may escape at the expense of its tail.

The man in the boat may punt himself along by pressing with a pole against the bed of the stream. He uses a lever against a more or less solid basis, and that is the essential thing in all forms of walking, running, and leaping.

Walking, Running, Leaping.

What a variety of pictures one sees! The galloping horse, the swift ostrich, the giant tortoise lumbering along, the water-measurer walking on the surface-film of the pool, the harvestman among the stubble with stilt-like legs twenty times longer than the body, the reindeer with its hoofs spreading out on the snow, the sparrow hopping on the street, the kangaroo jumping, the toad moving slowly like an old man, the lizard jerking itself across our path, the centipedes wriggling—but in all cases there is the use of levers against a more or less hard surface.

When an animal climbs with its hands and feet it is usually illustrating the boat-hook mode of progression; it fixes a limb and draws the body in various ways towards the point of attachment. But there is often a pushing upwards as well as a pulling, and two distinct methods are combined. The same holds when there are adhesive organs, as in the gecko running up the wall or the fly on the window pane; there is often pushing as well as pulling.

The variety is so great that it will be most profitable to take a particular case—the way of a serpent on the rock. It is one of the modes of motion that requires some thinking out—walking without legs.

The Way of the Serpent.

The snake has a large number of vertebræ, which are freely mobile on one another from side to side, yet without any risk of dislocation; they have deep ball-and-socket joints, and at each end two pairs of interlinking pegs ("articular processes") instead of the usual pair. Moreover, a wedge-like prominence on the front surface of each vertebra fits into a corresponding cavity on the hind surface of the one in front. These arrangements, in addition to the binding bands or ligaments, make it possible to jerk the body or part of the body instantaneously straight without risk of dislocation. For one of the snake's modes of locomotion is to launch itself forward by a sudden straightening of the bays of its sinuous body. This is an undulatory or wavy kind of movement, which the snake also shows when it is swimming. It might be described as sideways wriggling, and it will be

Photo: John J. Ward, F.E.S.

LARVA OF GNAT.

This aquatic larva propels itself by rapidly bending and straightening the posterior body. It is continually jerking itself from the bottom of the pool to the surface. The photograph shows the breathing siphon near the tail-end.

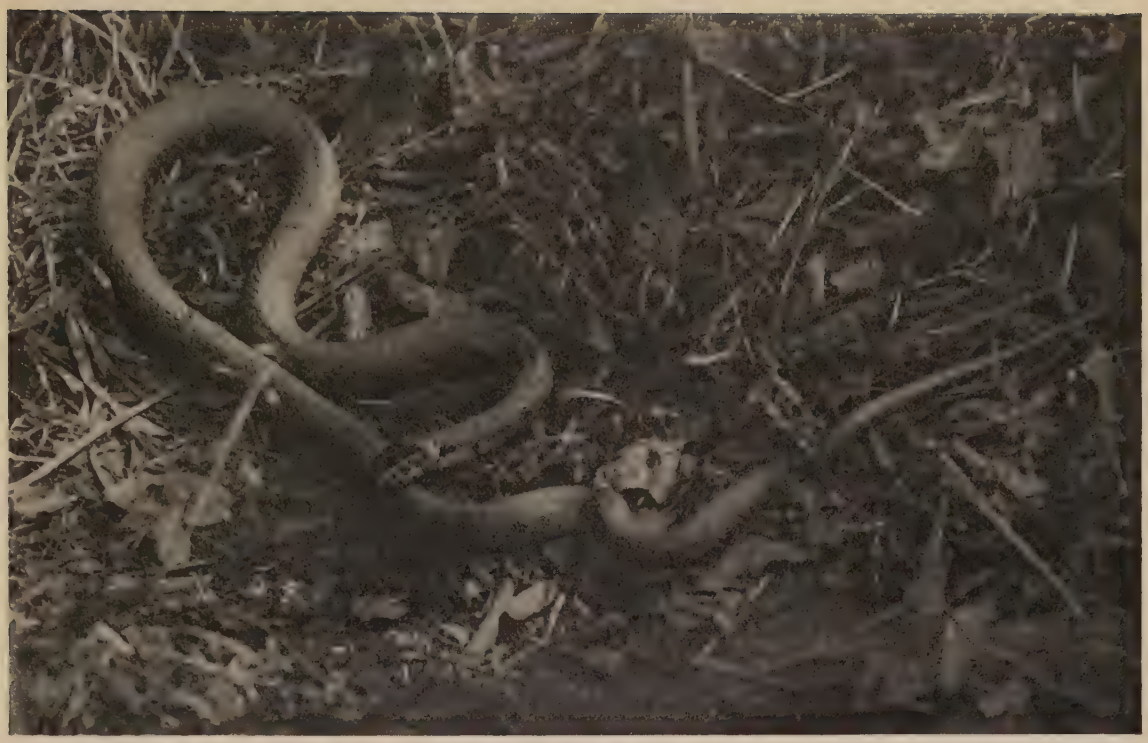


Photo: John J. Ward, F.E.S. COMMON GRASS SNAKE.

The grass snake (*Tropidonotus natrix*) is a harmless English snake, usually about a yard in length and variable in its colouration. It likes moist grassy places, and feeds on frogs and fish. It swims beautifully, but it can also climb on shrubs. The eggs are laid among vegetable mould or the like. The young require to learn how to behave in water.

Photo: James's Press Agency. DIAMOND PYTHON.

The diamond python is a harmless Australian snake, of a dark colour with numerous yellow spots. The photograph suggests the two kinds of movement. The posterior body is being levered forwards by the action of the ribs, two of which are fastened to each ventral scale. The anterior body is being jerked forward by the sudden straightening of a bend.

clearer when undulatory swimming is discussed in the next chapter. But in addition to the wavy wriggling there is a complicated leverage by means of ribs and scales.

The great anatomist, Sir Richard Owen, writes: "If the observer has the nerve to lay his hand flat in the reptile's course, he will feel, as the body glides over the palm, the surface pressed, as it were, by the edges of a close-set series of paper-knives, successively falling flat after each application." These "paper-knives" are the large ventral scales which cross the under-surface of the snake's body—one scale extending the whole way across at any given point. Part of the secret of the snake's gliding is to be found in the contraction of skin muscles which raise the scales so that their strong hind margins catch on the ground. But each scale is also attached by ligaments to a pair of elongated ribs, and what happens is that the ribs, which are moved headwards and tailwards by muscles, pull on the fixed scales and thus draw the body forward. There are sometimes three hundred vertebræ, and all of these except the first and those of the short tail, bear ribs. The tailward movement of a pair of ribs tends to pull a raised scale backwards, but the scale is gripping a roughness on the ground, and the result is to lever the body forwards. While one set of ribs is being drawn backwards, another set is being drawn forwards, and similarly the ventral scales of one region of the body are raised while in another region they are sinking into place again. There is a complex multitude of leverages. As Ruskin said: "The snake literally rows on the earth with every scale for an oar; it bites the dust with the ridges of its body." A "nullipede," without any legs, has become, as it were, a "multipede" with two hundred or more pairs of ribs which act as legs.

"It is true," Sir Richard Owen said, "that the serpent has no limbs yet it can outclimb the monkey, outswim the fish, outleap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the air and seize the bird upon the wing; all these creatures have been observed to fall its prey. The serpent has neither hands nor talons, yet it can outwrestle the athlete, and crush the tiger in the

Photo: F. W. Bond.

COMMON BOA (*Boa constrictor*).

The boa constrictor, whose scientific name is also used as the popular name, is a South American relative of the pythons. It is a non-poisonous, strangling snake, of enormous strength. Not uncommonly it attains to a length of ten feet. The prey is often crushed into a sausage before the tedious process of swallowing begins.

embrace of its ponderous overlapping folds." Outclimb the monkey, outswim the fish, outleap the jerboa, outwrestle the athlete, and crush the tiger—surely a miracle of mobile strength. There is nothing, says another enthusiast, that a snake cannot do, save cross a horse-hair rope, get off a sheet of perfect ice, and swallow a porcupine.

When all is said, the most interesting feature is the effectiveness with which the snake's loss of limbs has been counter-balanced. There can be no doubt as to the origin of snakes from lizard-like ancestors. The origin is proved by the tell-tale vestiges of limbs and girdles that are present in some snakes. Moreover, there are not a few lizards which show various stages in the evolutionary process of losing limbs. The resulting limblessness is no doubt an adaptation to movement through narrow spaces and dense brushwood, and sometimes to burrowing. But the point is that the disappearance of the proper organs of locomotion has been met by the elongation of the ribs, their spreading all along the backbone except on the very short tail, and attachment to the exaggerated ventral scales which grip the ground.

Photo: W. S. Berridge, F.Z.S.

RINGHALS SNAKE (*Sepedon hæmachates*).

This South African snake, whose name, Ringhals, means "banded neck," is a relative of the cobra. It is black above, variegated with yellow or pale brown, and black below, banded with some white across the anterior body.

XIX

SWIMMING AND FLYING

SO many different kinds of animals are at home in the water that there are bound to be many different kinds of swimming. Let us take a first glance and then try to classify them. The duck swims with its feet, the water-ouzel in the mountain-stream uses its wings and we have seen it go both with and against the current. The skate swims with its fore-fins, which are flattened out into great triangles ; the eel swims with its whole body. An ordinary fish flicks its tail from side to side ; but a whale, which is a mammal, works its tail-flukes from above downwards. Jellyfishes (Medusæ) and Swimming Bells (Medusoids) swim by jerking out water through the narrowed opening of their flexible transparent umbrellas or domes ; a Sea-Horse swims with a beautiful undulatory movement of its unpaired dorsal fins. Most aquatic insects swim by using their legs, especially the hindmost pair, as oars ; the crayfish, which is a crustacean, swims tail foremost by rapidly bending downwards and forwards its six-ringed posterior body which ends in a fine pair of paddles. The sea-snakes undulate their body from side to side, and there is a lateral flattening of the tail-region, and sometimes of part of the posterior body as well,

which gives the reptile more grip of the water. Thus there are many ways of swimming; can they be arranged in groups?

Undulatory or Wavy Wriggling.

When a water-leech is not in a hurry it moves by looping along, as we have already seen, but when it is excited it swims, and a very beautiful swimmer it is. The body is more strap-like in swimming than it is in looping, and waves of muscular contraction pass quickly from head to tail, just like the up-and-down waves that can be made with a long belt or a rope. It comes to this that there is an alternate making and unmaking of bays along the upper and lower (dorsal and ventral) surfaces of the leech's body, and the result is to displace little masses of water upwards and downwards. Thus the leech wriggles on—in a direction opposite to its muscle-waves.

In some worms like the Horsehair worms and distant relatives of the earthworms that are called Naïds the wavy motion of the body is from side to side, not up and down; and this lateral waviness is what one sees in fishes. Apart from sea-horses and a few other exceptional forms, fishes cannot move their backbone vertically, but only from side to side. Sometimes, as in eels, the wavy movement extends over the whole body, but there is a tendency to restrict it to the posterior region which in ordinary language would be called the tail. But it is more than the tail, for in an ordinary fish, like a cod or a mackerel, the hind half of the body or thereabouts is solid muscle. Through the skin one may see W-shaped markings which are the boundaries of blocks of muscle fastened to the backbone and dovetailed into one another.

What happens when a fish swims is that masses of water are thrust out laterally by a straightening of the bays on the sides of the body. The character of the swimming will depend on the number of these bays, on their depth or shallowness, and on the rapidity with which the undulations succeed one another along the body. The displacing of the water may be greatly helped by the tail fins which often take a good grip of the water. It must be understood that the *paired* fins of fishes, which correspond to our arms and legs, are rarely used for more than balancing and very gentle locomotion.

Photo: James's Press Agency.

SEA-SNAKE.

In adaptation to swimming there is a sideways flattening of the tail and sometimes of the posterior trunk as well. There are no enlarged ventral scales. The eyes are small. Sea-snakes are very poisonous and range from the Persian Gulf to Central America.

The sea-snakes are fine examples of the wavy method of swimming. They move like eels and lampreys, with lateral undulations, and they are assisted by a posterior flattening from side to side. The British Grass Snake and Adder are both good swimmers, but they are truly at home on land, whereas the sea-snakes never come ashore unless to bring forth and nurture their young ones.

In contrast to cases like the sea-snakes, where the muscular waves run along the whole body, there are many cases where they are

Photo: John J. Ward, F.E.S.

SEA-HORSES (*Hippocampus*),

among the most whimsical fishes, not uncommon in the Mediterranean, occasionally found off the English coast. They live in a leisurely way among the seaweed, anchoring themselves by means of their prehensile tails. On the middle of the back there is a rapidly vibrating fin, for use in gentle swimming. The father-fish takes charge of the eggs.

Photo : Neville Kingston.

THE AMERICAN BOWFIN, SWIMMING WITH DORSAL FIN ALMOST STRAIGHT.

Photo : Neville Kingston.

AMERICAN BOWFIN, SWIMMING WITH DORSAL FIN UNDULATING.

The bowfin (*Amia calva*) is common in rivers and lakes in North America, and is a voracious carnivorous fish. A rough clearing is made among water-weeds, and there the eggs are laid. The male mounts guard, and even when the fry leave the so-called " nest " he continues to look after his family. The movements of a typical fish, beautifully shown in these photographs, consist mainly of lateral displacements of the water to each side alternately. The instrument or engine is the posterior part of the body, which is almost sheer muscle. The unpaired dorsal fin increases the grip of the water. The paired fins help in balancing.

Photo: W. S. Berridge, F.Z.S.

SQUID (*Ommastrephes sloanii*).

This squid is a cuttlefish belonging to the group of molluscs, not at all related to true fishes. It has eight short and two long arms, all with suckers.

localised in particular structures. Thus in squids and other active cuttlefishes there is an undulatory movement of a longitudinal fin on each side of the body. This wavy swimming is in addition to another method—altogether unique—which all cuttlefishes exhibit: they have a funnel through which they squirt out water with such force that they are driven along, head behind. The fin movement in some of the squids is remarkable since the direction of the muscle-waves can change, and the creature can swim with the head in front, though it usually swims with it behind. The wavy swimming is sometimes strong enough to lift the body clean out of the water.

Another instance of localised waviness is to be found in the skate. The body of this gristly fish has undergone flattening from above downwards, and the posterior region or "tail," which is the locomotor organ in ordinary fishes, is narrowed and elongated, becoming in some cases, such as the sting-ray, a formidable weapon. Not only can it lash like a whip, it sometimes bears a barbed spine that gives an ugly wound. Now in skates the place of the ordinary motor, which has been relinquished, is taken by the greatly expanded pectoral fins. These big triangles show up-and-down undulations, from in front backwards, the vertebral column remaining unbent. For, as we have already said, it is very unusual for fishes to be able to bend their backbone in any direction save sideways.

The Skate.

To this rule it may seem at first sight that bony flatfishes, like soles and flounders, form an exception, for we see them move horizontally, with a beautiful vertical waviness over the whole body. It is interesting to watch these up-and-down undulations on a small plaice or dab in a shore-pool. But they are just the usual lateral waves of fishes, for the bodies of plaice and dabs, soles and flounders, and their relatives undergo in the course of the life-history a remarkable flattening from side to side. They do not rest

Photo: W. S. Berridge, F.Z.S.

CUTTLEFISH (*Sepia officinalis*).

Another cuttlefish is the common sepia, which used to furnish sepia for the artists. The photograph shows the interesting funnel through which water is squirted out—a quite unique way of swimming.

Photo: John J. Ward, F.E.S.

A FIXED JELLYFISH OR LUCERNARIAN (*Haliclystus*), WITH UMBRELLA CONTRACTED.

This is a peculiar kind of jellyfish or medusa, for it is fixed by a stalk to the rock or seaweed, mouth upwards. The margin of the umbrella bears eight groups of short adhesive tentacles.

and swim on their ventral surface like the skates, but on one side, either right or left. The majority rest and swim on their left side, which is the heavier; brill, megrim and turbot may be mentioned as bony flatfishes that swim on their right side. The important point is that the wavy movement of the body in all the bony flatfishes is the usual lateral waviness.

The Sea-Horse.

Another very interesting wavy movement is seen in the single dorsal fin of the sea-horse, a whimsical fish that anticipates monkeys in having a prehensile tail, which is also very remarkable among fishes in moving from above downwards. It is a delight to watch the sea-horse moving slowly among the seaweed, like a living point of interrogation, toppling forward and then straightening again. The motor is the dorsal fin which shows beautiful undulations and beats fifteen to twenty-five times in a second, driving the fish about an inch and a half forwards in that time. The sea-horse's swimming is not much to boast of as regards speed, but the gracefulness and the unconscious humour of it!

Propeller Swimming.

The more the muscular waves of a fish are restricted to the posterior part of the body, and the more the numerous undulations seen in an eel are replaced by single brusque "flicks" of the "tail," alternately to right and left, the more is wavy swimming replaced by propeller swimming. But there is no hard and fast line of separation. We say "propeller" swimming, but of course the fish propeller does not go round, it delivers its thrusts alternately from side to side. There are very interesting adaptations in the shape of the tail, thus the upper lobe is very much the larger in sharks and the sturgeon, and the effect of the strokes is to depress the head, thus bringing the ventrally situated mouth nearer the bottom where the fish finds its food. In the extinct fish-lizards or Ichthyosaurs it was the lower lobe of the asymmetrical tail that was much the larger, and the strokes would tend to bring the head upwards—a useful arrangement in aquatic reptiles that had to take air into their lungs at the surface.

Photo: John J. Ward, F.E.S.

FIXED JELLYFISH OR LUCERNARIAN WITH UMBRELLA OPEN (SEEN FROM ABOVE).

Between the eight tufts of short tentacles the photograph shows eight sense organs. In a line with the tentacles are eight reproductive organs.

Specially drawn for this work] [*by Richard Ogle.*

A LARGE JELLYFISH SWIMMING IN THE OPEN SEA, WITH YOUNG FISHES SHELTERING BENEATH THE UMBRELLA.

Jellyfishes or medusæ are free-swimming Open-Sea animals. They swim by altering the curvature of the saucer-shaped umbrella. The contraction of the under surface drives out water from beneath, thus propelling the body onwards. The disc or umbrella may be two feet across or more. Four frilled lips and numerous stinging tentacles stream out behind. Linkage is illustrated by the way the young of the horse-mackerel (*Caranx trachurus*) seek shelter below the disc.

The propeller method is finely illustrated by porpoises which are often seen gambolling not far from shore. There is an up-and-down wavy movement in the posterior body, but the main motor is in the horizontally expanded flukes of the tail. There are vertically twisting thrusts, not lateral as in fishes, and every half minute or so we see, in succession at the surface, the dolphin's snout, the fin on the middle of its back, and the tail-flukes. There is often an almost irresistible illusion that the creature is somersaulting. The balancing flippers are pressed close to the body when the creature is moving quickly. At intervals we hear the sob of the outbreathing.

In the Common Seal the hind legs are shunted backwards on each side of the short tail, and they form a complicated propeller on a very different plan from the dolphin's. Also of the propeller type is the laterally compressed tail of the crocodile. Or, to change the comparison, one may say that the crocodile sculls itself along with its tail. The strokes are very powerful and a captured giant has been known to kill a man with one blow.

A third kind of swimming is by rowing in the water. That is to say, the animal uses limbs of some sort as levers to press masses of water backwards. Among mammals this is well illustrated by the beaver and the otter, in both of which the strong tail is mainly a rudder. It is horizontally flattened in the beaver, cylindrical in the otter. In the fur-seals the fore and hind limbs are powerful oars or paddles, so their swimming is different from that of the common seal.

Swimming by means of Oars.

Most of the swimmers among birds use their feet, but in penguins the flightless wings are the important oars. The puffin "flies under water," the feet trailing behind, very much as they do in aerial locomotion. This use of the wings in swimming is true of other members of the auk family, such as guillemots and razorbills, but some use their feet as well as their wings in diving. In the true divers the feet are the important motors.

The secondary use of the wings as swimming organs, which is *beginning* in the water-ouzel and perfected in the puffin, is rather interesting; the birds simply continue under water the movements utilised in flight. One is reminded that

Photo: Leo Warmsley.

DOLPHIN LEAPING.

The dolphin (*Delphinus delphis*) is one of the small whales or cetaceans, about six feet long. It can keep up with a steamship. Its propelling engine is the muscular posterior body which moves vertically in the water, beginning with very strong strokes, but subsiding into a tremble when full speed has been secured. The flukes of the tail are not muscular, but serve as blades that can be adjusted in rigidity according to the speed.

land-mammals, like horses or dogs, when tumbled into water, usually swim by continuing their walking movements—a method which, unfortunately, does not work in man's case.

Another fine swimmer is the Diving Petrel called Pelecanoides, a near relative of Mother Carey's Chicken, deceptively like a Little Auk, to which, however, it is not related. It is a bird of the open sea and an expert diver. It disappears instantaneously, and swims swiftly with its wings, emerging again *in flight*. There is a touch of perfection in that.

A turtle swimming by means of its flippers is a good example of the rowing method, and so is the frog which swims by powerful back-strokes of its large webbed feet. Among crustaceans the rowing method is very common: many a water-flea uses its feelers or antennæ, and the swimming-crab (Portunus) has the last pair of walking legs transformed into paddles. Many water-insects swim with their legs, especially the third or hindmost pair. The water-boatman (Notonecta) rows about, back downwards.

A survey like this shows the great variety of ways in which the same result may be achieved, but most of the methods can be grouped under the three headings—wavy or undulatory wriggling, propeller or screw progression, and rowing in the water with oars. This does not exhaust the possibilities, however, and there is one that crops up among so many different kinds of animals that it cannot be overlooked—it is the method of jerking out water with considerable force through a narrowed opening.

Other ways of Swimming.

In jellyfishes (Medusæ) and swimming-bells (Medusoids) there is a beautiful throbbing movement. The transparent umbrella or dome is suddenly contracted and the water within it is forced outwards through the narrowed opening. It is a leisurely kind of swimming. In the chapter on cuttlefishes a full description is given of their quaint way of swimming by forcing water out through a narrow funnel. The same sort of thing is seen in the unexpected swimming of scallops. The strange creatures called Salps and the brilliantly luminescent Fire-flames or Pyrosomes, sometimes as long as a man's arm, propel themselves by forcing water out at one end. Then there is the quaint swimming of the larval dragonflies, which take water into the posterior end of the food-canal, where it helps in respiration, and drive it out again with great force, thus forcing themselves forward. There seems no end to the variety of ways in which animals have solved the problem of moving effectively in the water.

Photo: G. C. S. Ingram.

HERRING GULL, DIVING FROM A CLIFF.

When a bird launches itself into the air from a height, it holds its wings out taut, and glides. By altering the tilt of the wings, but without strokes, it can rise after a considerable descent, and thus pass from a greater height to a less. If there is wind the case is more complicated.

Swimming leads on to diving and one must distinguish two methods. In most cases the creature propels itself into the water, using its feet almost solely in the true divers, like the Great Northern Diver, using its

Diving.

Photo: Neville Kingston.

PENGUIN SWIMMING UNDER WATER AND ABOUT TO SEIZE A FISH.

Penguins are adept swimmers and divers, clever in catching fishes, but depending to a large extent on prawn-like crustaceans. The flipper-like wings serve as paddles under water, and there are very powerful wing-muscles. Thus, though the penguin is flightless, it has a very strong keel on the breastbone. As it comes near the surface again, it uses its feet as propellers. The photograph is an achievement when one thinks of the speed of the bird.

wings only in the Puffin, using both hands and feet in the Otter, using the tail-flukes in the Whales, and so on. The rarer method of diving is to enter the water at a considerable speed and continue on the strength of it. The Kingfisher drops from a perch or from the air where it has been poising head downwards with rapidly vibrating wings. The Water-ouzel or Dipper often dives into the stream after a rapid flight, but it can use its wings under water and it can grip the stones with its feet when it is securing the insect larva. The Common Tern poises with vibrating wings and suddenly drops down with a curious twist, entering the water with a splash, but not usually submerging itself.

The finest of the high divers is the Solan Goose or Gannet, whose behaviour may often be watched round British coasts. Its diving is one of the common sights of the Firth of Clyde. The bird nests on a few more or less inaccessible rocks like the Bass Rock and Ailsa Craig; it winters for the most part in the open waters of the North Atlantic. It is exclusively a fish eater and swallows its booty under water. It is not in any way related to geese.

The Solan Goose.

Photo: Riley Fortune, F.Z.S.

GANNET "PLANING."

The gannet or Solan goose (*Sula bassana*) is one of the birds with great facility in "planing" or "sailing." Having attained a considerable momentum it continues moving for a time without a single wing-stroke.

What one usually sees is something like this. The Solan Goose, having just swallowed a fish, rises from the water, which must be a great effort—the first step which costs. With powerful strokes of its long pointed wings, sometimes six feet in span, it rises gradually and not very quickly against the breeze. The more wind there is the sooner the bird ceases to strike the air. It shortens its neck, shunting the centre of gravity of the body well back, it spreads out its tail, it holds its wings like a great obtuse letter V, with the outermost parts tilted up. The bird "sails" upwards in the eye of the wind. It reaches an altitude which will depend on the momentum it gained by its wing-strokes, on the force of the wind, and also on the number and depth of the herring in the water below. It often ascends a hundred feet, but it may reach a height of more than twice as much.

If there is no shoal visible, the bird turns, and, altering its attitude in the air, sails *with* the wind, losing some energy of position, but not necessarily very much, and often gaining in speed without a stroke of its wings. This speed is utilised again if the bird turns and sails upwards once more against the wind. We see this singularly beautiful alternation—with the wind and against the wind—as the bird shifts from place to place, or goes over the same ground again, searching the water with careful scrutiny.

But if from its maximum height the bird discerns its booty, it lengthens out its neck, bringing the centre of gravity of the body forwards, and planes downwards with half-closed wings, sometimes in a slope, sometimes vertically. It attains a great velocity; it closes its wings; it enters the water with a splash and disappears. The reappearance may be at the same spot or a little way off. Then the story begins again, but the bird often turns again and enters the water from a few feet above the surface. Perhaps this is when it sees an easy victim. The whole performance is masterly.

The atrociously cruel trick has been played of sinking a board below a dead herring, with the result that the diving bird is killed by the terrific impact of its skull against the wood. But terrible things happen apart from man's ruthlessness, for a diving gannet may run its beak right into the mouth of a gaping fish, killing the fish but also killing itself. For it may be unable to extricate itself and is drowned. But this is the sort of mishap that may not occur once in a million dives.

Flying.

The problem of flight has been solved four times—by insects, by the extinct Flying Dragons or Pterodactyls, by bats, and by birds. All the four solutions are different. In insects the wings are flattened elastic membranes arising from the upper part of the sides of the second and third rings in the middle region of the body. They are supported by ribs or nervures, something like the ribs of a fan, and they are worked by powerful muscles.

Photo: Knox Fortune, F.Z.S.

THE GANNET "PLANING" OR "SAILING."

The gannet has a superlatively fine flight, with a six-feet spread of wing. It attains a high velocity; it "sails" or "planes" against the wind; it plunges headlong with half closed wings, it closes them and dives; it reappears weighted with a swallowed fish, and after some strenuous flaps rises high again.

Photo: Riley Fortune, F.Z.S.

TWO KITTIWAKES IN FLIGHT, SHOWING TWO POSITIONS OF THE WINGS.

The kittiwake (*Rissa tridactyla*) is a small northern gull, resident in the British Isles, nesting in large numbers on the insecure ledges of precipitous cliffs. It is a bird of powerful but easy flight, and spends much of the winter in the open sea. It is said to be able to accompany liners across the Atlantic, but it must be difficult to prove this for individual birds.

The flight depends on the rapidity of the beats, sometimes over 200 in a second. The Pterodactyl's wing was a web of skin supported by the greatly elongated little finger. The bat's wing is also a web wing, spread out by the arms, hands, and legs. But the bird's wing is on a different plan, for the sail-portion is due not to a web but to the feathers, which enable the bird to have a large striking surface without great weight.

In the chapter on the life of the forest an account will be found of the parachuting or volplaning animals, like the "flying" squirrels, which throw themselves through the air from tree to tree. Here we shall keep to the true flight of birds.

If we watch a bird in ordinary flight, we see that the wings begin vertically above the bird's back, and, in the case of the pigeon, we can hear them strike together with a loud clap. Then the wings move *forwards, downwards,* slightly *backwards,* and then *upwards,* till they clap against one another again or come near doing so. For centuries it has been usual to compare the flight of a bird to the rowing of a boat, and in a general way it is true that the bird rows in the air with its wings as oars. But there are two big differences to be noticed. The boat floats, whereas the bird has to keep itself up by constant effort. Moreover in the stroke of the oar there is a large backward component, whereas in birds the backward part of the stroke is much less marked. In the case of the rowing boat the oars displace a large mass of water *backwards,* but in the flight of birds the wings displace a mass of air more *downwards* than backwards.

Ordinary Flight of Birds.

Perhaps the ordinary flight of a bird might be usefully compared to swimming with the arms and hands only. The downward part of the stroke keeps the swimmer from sinking, the backward part drives him through the water. But, as we have said, the backward stroke of the wing is less than one would expect. So there is something to be said for the comparison used by a French zoologist, M. Magnan, who is also very familiar with man's various flying machines.

Photo: Riley Fortune, F.Z.S.

KITTIWAKE ON WING.

This photograph must be taken along with that above. The three birds together illustrate very clearly the positions of a bird's wings in flight. First of all the wings are almost vertically above the back, as in the uppermost figure. They are drawn forwards and downwards, then backwards, and finally up again.

He compares the flying bird to the movement of a strong man using crutches. Pressing hard against the ground with his crutches the man throws himself forwards, pulling his crutches after him for another spring. So the bird presses down on the resisting air and leaps forward, sinking a little towards the end of its leap. The path in the air is an undulating one, even when the undulations are very slight, so quickly are the aerial crutches worked. Many small birds like pipits leap through the air with wings pressed close to the body ; their flight is a succession of bounds. The hard work in flying is bringing the outspread wing downwards against the air, for the bird drives away from itself a large quantity of air, and it is the resistance offered by the air that enables the bird to keep afloat and to leap forwards. The larger the wing the fewer strokes will be needed per minute ; the smaller the wing the more rapidly must the strokes follow one another. A stork has 120 strokes in a minute, a crow 180–240, a wild duck 540, and a sparrow 780. But when the bird has got up a certain speed in the air the energy required is much reduced.

Gliding.

A beautiful kind of flight that is often to be seen is gliding. A bird with a large sail-area, like a gull, gets up a certain speed and then rests on its oars. It *glides* along with outstretched wings, like volplanes, but without any strokes. When a gull, flying seawards over the cliffs, meets a breeze in the opposite direction, but rising upwards off the face of the cliff, it often stops flying and begins to glide, *rising* like a kite. In ordinary cases without wind the gliding soon comes to an end, for the bird loses velocity and loses height. We see gliding when a pigeon launches itself from the dovecot and comes gracefully to the ground, putting a brake on at the last moment. Still finer is the sight of a hawk swooping from mid-air on its victim, and, then, having missed it, gliding up again without a pause and without an effort. Sometimes, at any rate, there does not seem to be a single wing-stroke until the hawk has risen many feet off the ground.

The Albatross.

This giant among flying birds inspires respect rather than affection. It may be bigger than a goose, and sometimes attains to eleven feet four inches from tip to tip of outstretched wings. Except when it eats so much that it cannot rise, it is eminently "capable" in its mastery of wind and wave. It keeps up with the ship without

Photo : G. C. S. Ingram.

BLACK-HEADED GULL RISING FROM ITS NEST.

This small gull (*Larus ridibundus*) is common throughout Europe and most of Asia. It is a partial migrant in Britain, for while many leave for the south in autumn, there are many that stay.

Photo: Captain H. Morrey Salmon, M.C.

BLACK-HEADED GULL IN FLIGHT.

This gull has a very interesting way of flying, somewhat suggestive of a tern, as if it were continually changing its mind or wavering. The wing-strokes are very rapid, and the whole flight is well suited for hawking insects in the air. For though this gull will eat most things, it is by choice an insect-eater, and does good service to the farmer in devouring the injurious leather-jackets and wireworms. It has no power of diving after fish.

effort, and sails round and round the vessel with sublime nonchalance. For half the year it is distinctively an open-sea bird; for the rest of the time the adults are preoccupied with long brooding and parental cares.

The Blackbrowed Albatross has been seen as far north as Britain and California, and there are other species that occur in Northern seas. But the genus is distinctively Southern. The Wandering Albatross or Great Albatross—the kind that the Ancient Mariner slew with his crossbow and afterwards carried round his neck—is most at home in the far South. Like most of the Southern sea-birds, it belongs to the petrel order. Its proper name, Diomedea exulans, recalls an old story of exiles who were turned into birds — probably shear-waters, however. The Spanish-Arabic word albatross is said to mean water-bucket, and the sailors' name, "Molly-mauk," which is also applied to the fulmar, seems to mean "silly gull."

As everyone knows, the albatross is famous for its "sailing" or "soaring"—the most wonderful of all modes of locomotion. As Mr. Froude said, it "wheels in circles round and round, and for ever round the ship—now far behind, now sweeping past in a long rapid curve, like a perfect skater on an untouched field of ice. There is no effort; watch it as closely as you will, you rarely or never see a stroke of the mighty pinion." This "sailing" flight, in which the bird describes magnificent ellipses round the ship, apparently without a stroke of its wings for half-an-hour at a time, requires some breeze, and many authorities believe that the albatross takes advantage of the unequal velocity of air-currents at different heights. In going down the wind the bird sinks a little, but acquires increased velocity; then by wheeling and tilting its body it turns against the wind and rises again with reduced velocity, changing energy of locomotion into energy of position. This should be compared with the achievements of the modern "gliders."

In "sailing" there are no visible strokes in the ordinary sense, but it is possible that the bird gives very minute marginal beats, such as an oarsman, having attained a great speed, might give with the tips of his oars.

This heretical view is supported by some observations in Professor H. N. Moseley's "Naturalist on the *Challenger*": "I believe that the albatrosses move their wings much oftener than is suspected. They often have the appearance of soaring for long periods after

Photo: Captain H. Morrey Salmon, M.C.

BLACK-HEADED GULL ALIGHTING.

No doubt the head of this beautiful gull is coffee-brown, not black; but it is tiresome to try to change these old names. The favourite nesting-place or gullery is on marshy ground near a lake or pond, and there are often hundreds of nests close together.

a ship without flapping their wings at all, but if they be very closely watched, very short but extremely quick motions of the wings may be detected. The movements cannot be seen at all unless the bird is exactly on a level with the eye. A very quick stroke, carried even through a very short arc, can, of course, supply a large store of fresh momentum."

Albatrosses depend largely on fishes that swim near the surface, and thus they suffer in stormy weather. For they are not strictly diving birds. They splash into the water somewhat clumsily, and they have often to run along the surface for many yards before they can launch themselves once more into the air. They float buoyantly on the surface of the sea, and their large webbed feet are powerful in swimming. As its food-supply is sometimes precarious, the albatross often dines well, following Dougal Dalgetty's plan of provisioning for three days when the opportunity offers. The drawback is that they are sometimes quite unable to rise off the water.

Those who know albatrosses best say least about their beauty. Admirably fitted as they are for their task in life, their proportions are a little difficult for our eyes. The wings look far too long for the body. It must be noted, however, that five out of the six birds seen following the ship are young ones in immature brown plumage, often " dirty and draggled."

The albatross nests gregariously on islands, sometimes low, sometimes high. At Tristan da Cunha it has found a refuge within an old crater 8,000 feet above the sea. Another favourite place is on the top of Inaccessible Island. Sometimes, unluckily for the bird, the nesting places are readily exploited. At Laysan, for instance, in the mid-Pacific, the white albatross nests in such prodigious numbers that it pays to have trolley-cars for the collecting of the eggs. They are sent in shiploads to albumen factories and sugar refineries. The egg of the Great Albatross weighs about three-quarters of a pound, and makes a good breakfast plain boiled.

The nest is somewhat unusual, rising about a foot off the ground, like a big mole-hill with a depression on the top. It is made of packed earth, held together with grass and moss, and it is about a foot-and-a-half across the saucer-like hollow in which the single egg is laid. In the case of the Yellow-billed Albatross, oftenest called the Mollymauk, the nest rises much more abruptly, and has its upper margin overhanging. It suggests a tall hat turned upside down, but the concavity is merely a shallow saucer. The raising of the nest in both cases is probably in adaptation to the bird's very long wings, but in some situations it will have the advantage of raising the egg and the nestling off the damp ground.

The mother albatross sits very close, often with the male bird beside her. They snap their bills savagely when approached, making a loudish noise. When the brooding bird is forced to stand up, the large egg, nearly five inches long, slips out of a fold of skin in which it is held between the legs during the incubation. This is an interesting feature which finds its parallel among penguins. The brooding lasts for a long time, probably about two months, but the data are not very satisfactory. To some islands the wanderers come in October, leaving again at the end of March. It is probable that the young birds soon follow their parents out to sea, but there are records of their lingering for several months. If this is correct it means an unusual prolongation of the juvenile period, possibly in adaptation to the subsequent thoroughness of the pelagic life. It suggests that the albatross is long of reaching maturity.

During the breeding season the parents seem to reduce flying to a minimum. They waddle heavily over the ground, and are easily killed by ruthless intruders. Sailors used to make pipe-stems of the wing bones and tobacco pouches out of the webbed feet. The young albatrosses are dark grey in colour, and thus very different from their parents, who show white above, mottled with wavy bars, and brownish-black on the wings.

The albatross looks so eminently respectable (did not Coleridge call it "pious"?) that one is rather surprised to hear of courtship antics. Moseley describes the male's appeal as he stands beside the female perched on her mud nest. He raises his wings, spreads out his tail, throws up his head to heaven or stretches it straight out horizontally, and utters a curious cry, swaying his neck up and down. The female responds with a similar note, and they bring the tips of their bills lovingly together. This sort of thing goes on for half-an-hour or so at a time. No doubt, the birds consider that they are singing.

One touch of nature makes the whole world kin.

So, looking backwards, we see that there are three chief kinds of flight among birds—(1) ordinary flight, which is rowing in the air ; (2) gliding, which is like volplaning ; and (3) sailing, which is certainly difficult to understand. In the " soaring " of the lark, the wings are moving up and down with great rapidity, without there being any backward stroke. It may be compared to " treading the water," without moving from the spot.

XX
THE STORY OF THE EEL

OF all life-histories the strangest is perhaps that of the Common Eel, and it is only with recent years that it has come to be known with some approach to completeness. We shall begin with the eel nearest home, namely, in the ponds and quiet reaches of the rivers.

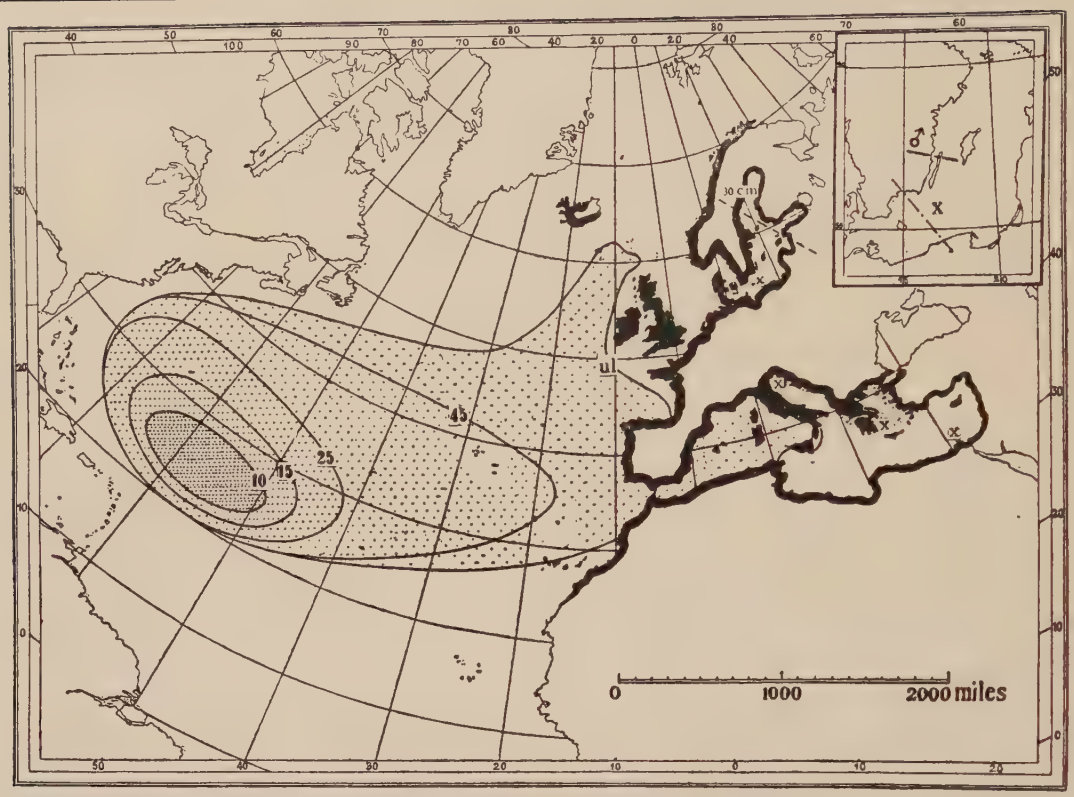
The cylindrical shape of the body is well suited for wallowing in the mud and creeping in and out among stones, and the eel likes to have things touching the surface of its body. A common length for a full-grown female is a yard ; twenty inches is about the limit for a male. The males take four-and-a-half to six-and-a-half years to grow up ; but the females take two years longer. It seems to be during these last two years that the female shoots ahead in size. During the growing time there is a good deal of yellow

Peculiarities of Eels.

Photo : W. S. Berridge, F.Z.S.

COMMON EEL (*Anguilla vulgaris*).

The common eel is marked by the smooth slipperiness of its body, for though there are numerous scales, these are minute and embedded in the skin in little groups. The pelvic fins are absent ; the gill-openings are small. Eels are voracious fishes, very tenacious of life, able to survive for a long time out of water.



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MAP SHOWING THE BREEDING-AREA OF THE COMMON EEL, AS DETERMINED BY JOHANNES SCHMIDT.

European eel (*Anguilla vulgaris*). *Spawning places* (bounded by innermost—10 mm.—curve) ; *distribution of larvæ* (dotted area) and of *adults* (black strip along the coasts where the eel occurs).

The curves show limits of occurrence ; i.e. larvæ less than 25 mm. have only been found inside the 25 mm. curve, etc. The outermost curve denotes the limit of occurrence of unmetamorphosed larvæ (*ul*), ♂ and 30 cm. (in the Baltic) of male eels and of eels less than 30 cm. in length. X : easternmost records of unpigmented elvers (Baltic and Mediterranean).

about the eel, along with tints of grey, brown and green ; but when they are becoming full-grown they put on a silvery dress. So the growing fish are called "Yellow eels" and the breeding fish "Silver eels." We may say at once that eels never breed in freshwater.

There are many peculiarities in the structure of eels. Thus there are no hind fins (corresponding to our legs) ; the mouth is particularly well suited for voracious eating ; the opening into the gill-chamber is very small, so that an eel can remain a long time out of water without great inconvenience, for the gills do not become quickly dry. There is no doubt that eels can move across a meadow from a pond to the river.

It is often said that an eel has no scales, but this is a mistake. There are plenty of them, but they are small and somewhat deeply embedded in the slimy skin. We can tell the eel's age by counting the rings of growth on the scales (*see* the Part on Life-Histories) but we must always add three years, for the eel does not show any scales till it is three years old.

The eel might almost be called a beast of prey. It is against all other fishes, and much more than that, for it devours worms, freshwater crayfishes, frogs, water-fowl, and water voles. In his very useful book, "British Freshwater Fishes" (1911), Mr. C. Tate Regan gives a curious example of the eel's range of appetite. "Not many years ago a large eel was captured in a pond near Sherborne by a labourer, who noticed a swan in difficulties and went to see what was the matter ; the bird had put its head under water and this had been seized by the eel, who would not let go until it was in the grasp of the man, who landed it." While eels will attack anything that they have any chance of swallowing, they are seldom devoured themselves except in their youthful or elver stage.

Eels are like owls, they hunt for the most part at night. The day is spent underneath stones or in the mud and sand. They are said to become restless during a thunderstorm. While growing

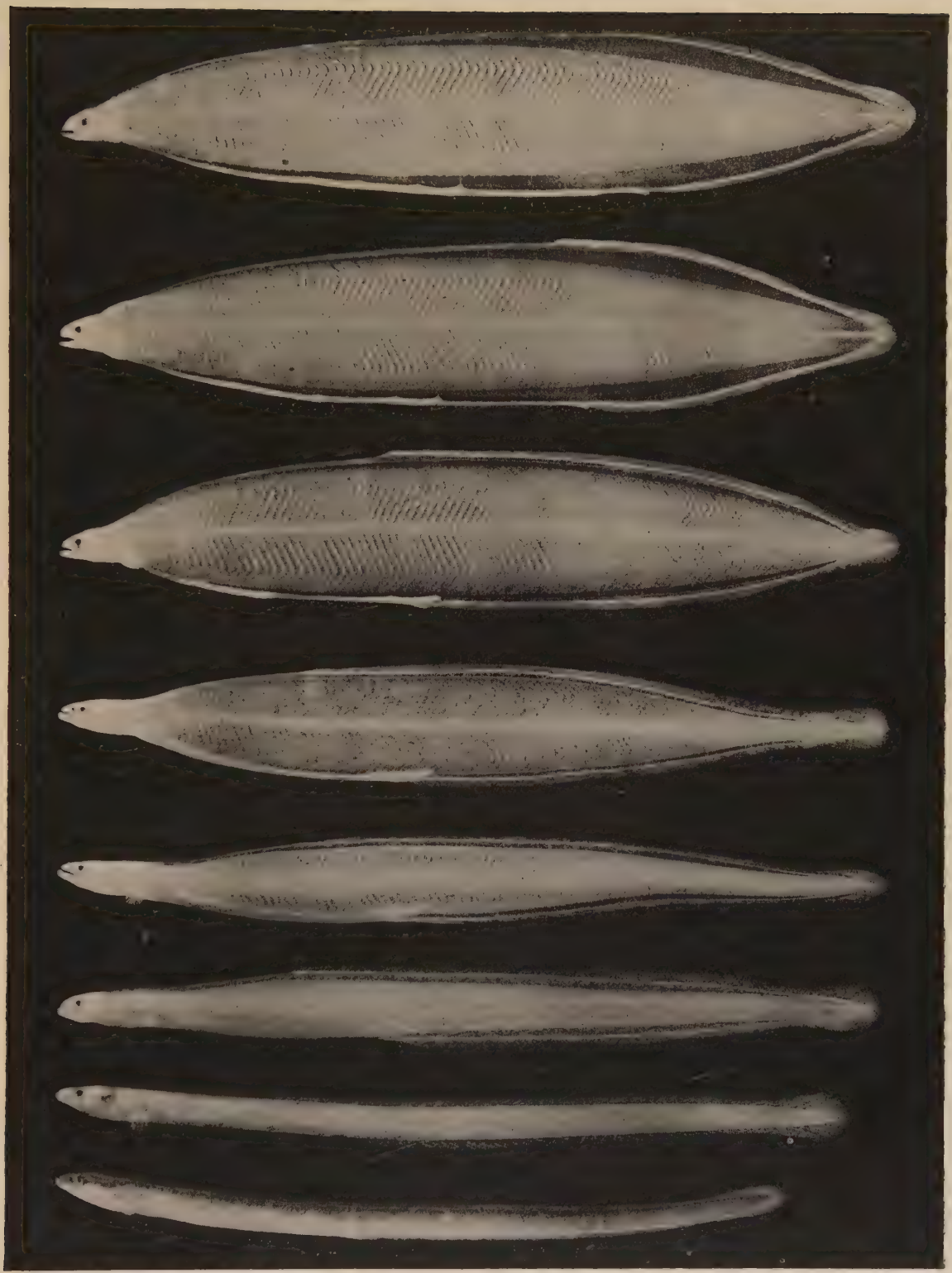

Photo: by kind permission of Dr. Johs. Schmidt.

METAMORPHOSIS OF THE COMMON EEL (*Anguilla vulgaris*) WORKED OUT BY DR. JOHS. SCHMIDT.
From the knife-blade-like Leptocephalus at the top, to the cylindrical elver at the foot.

eels are *for the most part* freshwater fishes, it must be noticed that some find suitable feeding places in the estuaries, or about harbours, or even in shallow shore-waters near river-mouths.

The Journey to the Spawning Ground.

After a variable number of years, the eels begin to be full-grown and ripe. Their appearance changes, as we have mentioned, for the colour becomes silvery below, the eyes become larger, the snout is less flattened, the fore-fins become longer and dark in colour. The eel is putting on its sea-dress. There is also a change in habits, for the eels lose their appetite and the food-canal shrinks. As the jaws are not being used much the muscles become smaller, and this changes the shape of the mouth. The composition of the blood changes also. For instance, there is more carbonic acid gas in it than there was before, and perhaps this has something to do with the restlessness that seizes the fish. It feels that it must set off on a journey, and the time for starting is usually the autumn and at nightfall. We have seen a throng of them coming down a river in the late evening.

There is sometimes a difficulty in getting out of the pond ; for instance, the sluice may be shut. But the restless eel may wriggle out of the water and travel for some distance over the damp grass. But there is another difficulty, that the fishermen, who know when to expect an " eel-run," place sugar-loaf-shaped nets in suitable places in the river, and catch the fish in large numbers. The flesh of " silver-eels " is preferred to that of " yellow-eels."

But many of the eels reach the sea, and that is the first stage in their journey. What has been discovered recently, especially as the outcome of seventeen years of research by Dr. Johannes Schmidt, is that the eels have a long journey before they reach a suitable place for breeding. From the Baltic, from the North Sea, and from the Mediterranean, they come crowding into the Atlantic. They cannot become quite ripe except in the sea, and not any sea will do. Thus most of the North Sea is too shallow for them, and where it is deep enough it is too cold. They have to go far afield. What Dr. Johannes Schmidt has shown is that the European eels have their breeding place in the western Atlantic, between about 22° and 30° North latitude and about 40° and 65° West longitude. The central part of the breeding area lies about latitude 26° N., nearly midway between the Leeward Islands in the West Indies and Bermuda. From this area, on one occasion, the net brought up close upon 800 very young eels. This single haul was enough to show that the cradle of the eels had been discovered. After spawning the parent eels seem to die. They never return to freshwater.

This is such a remarkable discovery that we must give Dr. Schmidt's own words. He pictures " hosts of eels from the most distant corners of our continent shaping their course south-west across the ocean, as their ancestors for unnumbered generations have done before them. How long the journey lasts, we cannot say, but we know now the destination sought : a certain area situate in the western Atlantic, north-east and east of the West Indies. Here lie the breeding grounds of the eel." Dr. Schmidt must have enjoyed a thrill of triumph when he wrote these simple sentences—condensing the patient inquiries and hard work of seventeen years.

The Open-sea Young Stages.

The free eggs of the eel are not yet known, but they are probably liberated in spring and early summer. Very delicate young ones (or larvæ), about $\frac{1}{3}$–$\frac{3}{5}$ of an inch in length, are found floating in water-layers about 600–1,000 feet below the surface, where there is very little light and a temperature of about 20° C. They feed on microscopic creatures and grow quickly, reaching an average length of about an inch in their first summer. They rise to near the surface (75 to 150 feet), or sometimes even to the surface itself. There they find themselves in the grip of an eastward movement of the surface-water, and they begin their journey towards the coasts of Europe. Before their first summer is over they are on their way, though they are still confined to the western Atlantic, west of 50° West longitude. We shall leave out for the moment those young eels that are going to America, and follow those that are going to Europe.

By their second summer the young eels are on an average about two inches long, and most of them are in the central Atlantic. What like are they ? A young eel in its second year is like a leaf or the small blade of a pen-knife. It is quite transparent, all but its eye ; it is like a living piece of glass. It must be noted that naturalists knew them long ago, in 1856, and gave them the

technical name Leptocephali, which means smooth-headed. But no one had any idea that these transparent Open Sea fishes were the young stages of the Common Eel. There are others like them which we now know to be the young of the big six-foot-long Conger Eel which does not leave the sea. But let us return to the journey.

In their third summer the young eels are approaching the coasts of Europe, and they are about three inches long. They are still like transparent knife-blades, but they are soon going to change their shape. They swim in a leisurely way with beautiful undulations of their leaf-like body, and they are able to float at rest, almost invisible in the water. Perhaps they escape the hungry eyes of sea-birds by being so glassy.

The Great Change.

In the course of the autumn and winter following the young eel's third summer, something very remarkable happens. The little creatures lose their appetite, and whenever animals do that, we may look out for some great change. The body changes from a knife-blade-like shape to a cylindrical shape, about the thickness of a bone knitting-needle. In the course of this change the young fish becomes lighter in weight and shorter. This is strange in a creature that is getting older, but the puzzle is solved when we remember that it is fasting. It is using the old material to build up the body on a new plan, and as it is expending energy without income, it must become lighter in weight. What is the result? The young eel has now become an elver, about two and a half inches in length, of a tougher constitution than before, ready to go up the rivers. It is about three years old, and it searches along the coasts for the river-mouths. Some have a much longer journey than others; it is easier to find the Severn than the Aberdeenshire Dee; the Mediterranean is less remote than the Baltic. Those elvers that ascend the Baltic rivers must have a journey of over 2,000 miles behind them!

The Eel-fare.

The elvers' ascent of the river in the Spring months is a striking sight to see. It is called by the Anglo-Saxon name "eel-fare," which means eel journey. There are such crowds of small swimmers that a thousand may sometimes be caught in a bucket. They prefer the sides of the river to the mid-stream rush of water, and they are, so to speak, wound up to go straight on. This is a curious point—the elvers are *automatically obliged* by

Photo by kind permission of Dr. Johs. Schmidt.

GROWTH AND METAMORPHOSIS OF THE AMERICAN FRESHWATER EEL, (*Anguilla rostrata*), AS DEPICTED BY DR. JOHS. SCHMIDT.

The youngest form at the top is 22 mm. long, that is, nearly an inch. The lowest form is a young elver.

their constitution to adjust their body so that the water presses equally on the two sides, and this keeps them straight. If they come to a tributary they may adjust themselves to the new current flowing in, and thus they go straight up the stream. The compulsion to go up and up must be very strong, for if they come to a waterfall they swarm up the wet moss-covered rocks at the sides and thus circumvent the difficulty. Some naturalists say, however, that those young eels that are going to be males some years afterwards are not inclined to go so far upstream as the future females do. They lag behind; the females press on.

But the upstream journey is continued only by day. We have watched the elvers passing in hundreds, the head of one almost touching the tail of another; but suddenly, when the sun went down behind the hills, there was not one to be seen. They had all snuggled under the bank or under stones.

In Switzerland eels have been taken in waters at an altitude of 3,000 feet above the level of the sea, and eels are abundant in the Lake of Constance, which is above the great Falls of the Rhine at Schaffhausen; but this is perhaps to be explained by the elvers getting round by some circuitous water-way. Sir Ray Lankester says in his delightful "Science from an Easy Chair" (1910), that he has trustworthy reports of the very rare occurrence of eels in streams connected with the Danube, yet there is no eel-fare in that river. "There can be no doubt that they have made their way individually into the Danube 'system' by migration through canals or ditches from tributaries of the Rhine or the Elbe."

The Niagara Falls are, of course, barriers to the upstream journey of the elvers, but an American zoologist, Professor Baird, writes that "in the spring and summer the visitor who enters under the sheet of water at the foot of the Falls will be astonished at the enormous numbers of young eels crawling over the slippery rocks and squirming in the seething whirlpools." He goes on to speak of hundreds of wagon-loads. But the Falls are impassable.

As to the occurrence of eels in shut-in ponds, it must be understood that elvers may ascend a drain-pipe or a driblet of water, and that they may press through a damp meadow. It sometimes happens, as in the North of Italy, that elvers are guided into suitable places; and they are often captured in places where eel-fares are thronged, and then introduced into ponds elsewhere. In any case many of them reach ponds and lochs after a prodigious journey; and that brings us back to where we began. Let us write the story down in summary: Full-grown "Silver-eels"—from ponds and lochs—by rivers—to the sea—the western Atlantic. Spawning and the death of the parents. The long journey of the glassy larvæ—the elvers—the eel-fare—the growing time of the "yellow eels."

XXI

THE BALANCE OF NATURE

CHARLES DARWIN, the greatest of all naturalists, first made it clear that all living things are intertwined into a harmonious whole, in which neither beast nor plant lives unto itself alone, but each is dependent on many other lives. There is an interlinked harmony, from which nothing can be taken away without influencing something else.

In the long run all animal life, including our own, is wholly dependent on plants for food. The golden eagle eats nothing but flesh, freshly killed if possible, but the flesh may be that of the rabbit or hare that feeds on the grass or the juicy leaves of plants. At another time it may be a bird that he carries home to his eyrie, and the bird too may be a flesh-eater, living on mice, frogs and dragonflies. But the mice had nibbled the corn-stalks, and the frogs and dragonflies had snapped up insects which had developed from the caterpillars that ate the leaves of our

Photo: T. Dobson, F.E.S.

CRESTED NEWT (*Triton cristatus*).

The crested newt is a handsome amphibian, occurring in ponds from Britain to Caucasia. At the pairing time the male puts on a high serrated crest along the middle of the back, and his dark colours are enlivened with yellow, orange, and even blue. The skin is slightly warty and very glandular.

gooseberry bushes, or from the grubs that made holes in the bark of the forest trees. However many links there may be in the chain, we are invariably led back at last to the plant, and without the plant none of the other forms of life would have been possible.

The reason is that the plant feeds at a lower level than any animal—with the exception of a few minute green forms—is able to do. The plant, by the aid of its green colouring matter, takes carbonic acid gas from the air, and through its roots it sucks up water and salts from the soil. These simple foodstuffs it works up, with the help of the sunlight, into starch, sugar, and other more complex compounds. These are stored in the tissues of the plant, and at this level they become available as food for animals. Thus the power the plant possesses of tapping the inexhaustible treasures of the atmosphere lies at the very foundation of all life.

But while this relation between plants and animals is fundamental, it is by no means the only one. If we were to try to keep a large aquarium and vivarium we should find that we should have to choose very carefully the animals and plants we put in, if we wished to avoid disaster. We should probably make many mistakes even then. The little vegetarian animals in the aquarium would grow too numerous, and would eat too many of the aquatic plants, and the water would then become so foul for want of the oxygen given off by the leaves that all the animals would die. The newts would not be able to hide effectively from the little water-snails, and these would pierce them through with their sharp-toothed ribbon-like tongues. Some of our pets would get their food too easily, and would soon consume the whole supply and then die of starvation. We should have to begin over again many times, and to make many experiments; yet, if we had patience enough, we should find in time the proper kinds and numbers of animals and plants that could live together as a well-balanced community.

An Aquarium.

It is just this kind of harmony, this state of balance, that Nature's age-long sifting has

Photo: John J. Ward, F.E.S.

COLORADO BEETLE.

This injurious American beetle (*Doryphora decemlineata*) owes its long second name to the ten lines on the wing-covers or elytra. The photograph shows the flying wings coming out from below the covers.

brought about. The balance is not the same all the world over, but varies in every area according to the conditions of climate, soil, and surroundings. Each area has its own particular association of plants and animals that are suited to the conditions, and that can live together, all finding sufficient food, often preying upon, but never exterminating one another, each species, not without effort, keeping its foothold but not usurping more than its due place in the general harmony.

Thus the balance is local, but even then it is not fixed; there are constant fluctuations, for the web of life is still a-weaving, and its pattern is continually changing. Sometimes an apparently small cause upsets the balance altogether for a time, but Nature sooner or later puts matters to rights again.

A Wave of Life.

One year on the plains of South America we are told, the spring was mild and early, and summer brought more frequent showers than usual. Everything flourished very luxuriantly; there was a wealth of flowers; the humble bees burgled them busily, and increased in numbers on the spoil. So far, good. But the mice followed the humble bees and fed on them voraciously. Prolific at all times, they became more so than ever; the litters were larger; the young matured more rapidly than usual, and soon had big families of their own. So before the summer was over there was a veritable plague of mice, and the whole land teemed with them. Round the settlements the dogs and cats hunted them continually, and even the hens became carnivorous for the time. Then the birds of prey began to gather; the owls and the hawks which used to migrate in winter would not leave this happy hunting ground. The mice themselves had used up their own food supply, and had become weak and sickly, so that when spring came again it was difficult to find a single mouse. They were not all gone, however, and in a few seasons they reached their normal numbers again, and the balance of Nature was restored.

Photo: John J. Ward, F.E.S.

THE TOAD, AN ENEMY OF THE COLORADO BEETLE.

The American toad (*Bufo lentiginosus*), which sometimes does useful work in devouring injurious insects, is very like the British *Bufo vulgaris*. Marked by its rough skin and fine eyes, it moves about in a leisurely way like a very old man.

Photo: S. Crook.

FIELD-VOLE CARRYING AWAY ITS YOUNG TO EMERGENCY NEST.

The short-tailed field-mouse or field-vole (*Microtus agrestis*) is common throughout Britain, but does not occur in Ireland. It does much harm by devouring all sorts of useful plants. It stores for the hard times of winter, but does not hibernate. The mother-vole is very solicitous for her offspring.

Photo : F. W. Bond.

INDIAN MONGOOSE.

The mongoose (*Herpestes*) is a lively, small carnivore, related to the civets. It is marked by sharp muzzle, loose fur, long tail, great agility, and unflinching courage. It is very useful in destroying rats and mice, and even snakes. The Indian mongoose is the Riki-tiki-tavi of Kipling's "First Jungle Book."

A Vole Plague.

In the last decade of the nineteenth century there was a plague of voles in the south of Scotland. We do not know what the cause of their excessive multiplication may have been ; it had probably been going on for several seasons, for life is slower in cold Scotland than in warm South America. But whatever the cause of the multiplication, the damage to the farmer was enormous. Fields of corn were ruined because the voles gnawed the stalks through so that they might get at the ears ; the grass was destroyed and the sheep suffered badly. All sorts of costly measures were devised for fighting the plague, yet the number of voles did not perceptibly diminish. But Nature had the matter in hand. In this case, too, the birds of prey were her chief instruments. Hundreds of pairs of short-eared owls nested in the infested area, where they had previously been quite scarce. They laid more eggs than usual ; their young ones throve rapidly, and by the end of the second season the voles had been reduced to almost their normal numbers.

Man's Disturbance of the Balance.

Man has often himself to blame for the disturbance of the balance of nature, from which he may be the chief sufferer. It is possible that, had there been less shooting down of hawks, owls, stoats, and weasels, there might never have been a plague of voles at all.

Sometimes man's agency in disturbing the balance of nature in a region is quite unconscious. When he settled in a new country, his life there, and the life of the domestic animals and food-plants he takes with him, may profoundly affect the fauna and flora of the region. But in time a new equilibrium is arrived at. The new plant and animal association may be different from the old one, but it will be harmonious.

We are told that in the mountains and forests of Central Europe every spot that has been used as a human abode can be identified by the plants that grow there, and the animals that visit them, long after every trace of man's habitation and handiwork has disappeared.

The Story of St. Helena.

Sometimes the introduction of domestic animals has a very direct effect. When the Portuguese landed on St. Helena in the beginning of the fifteenth century, they took with them many goats. The island was at that time covered with stately trees and a luxuriant undergrowth of plants. The goats could not do much harm to the big trees, but in the course of years they ate up all the undergrowth, and they nibbled every seedling as it came up, so that there was no

Photo: John J. Ward, F.E.S.

A BALANCE OF NATURE.

The owl—this is a young "Tawny"—preys upon—

Photo: John J. Ward, F.E.S.

the long-tailed field mice or bank voles—

natural renewal of the forest. In time the island—for it is a small one—became bare of trees, and round the coasts the heavy rains washed the fertile soil into the sea, so that the naked rock was exposed on the surface. There are springs and grass in the island now, but it is not very fertile, and animals can only gain a scanty living.

The Colorado Beetle.

When the cultivation of the potato in the United States of America spread westwards in the middle of the nineteenth century, a beetle, known as the Colorado Beetle, forsook its native food-plant, the Deadly Nightshade, of the Rocky Mountain area, and began to lay its eggs in the leaves of the potato. For the potato is nearly related to the Deadly Nightshade. The larvæ of the beetle hatched out and fed on the potato leaves for three weeks, at the end of which time they rolled themselves up into a ball and dropped to the ground to go through the last stage of their life-history. Another batch succeeded them, and then another, for the beetle lays three sets of eggs in a season. The beetle, in increasing numbers spread gradually eastwards by way of the potato fields, till in 1875 it had reached the Atlantic coast. Great anxiety was felt in Britain lest it should be carried across the ocean, but though a colony was found in 1901 near Tilbury Docks, the dreaded plague never really broke out. The Colorado Beetle still infests the potato-fields of the States, but methods have been devised to keep its numbers in check, and its ravages are no longer so serious. It has natural enemies in the Rose-Breasted Grosbeak, ducks, toads, and various insects.

Sparrows and Rabbits.

Sometimes a disturbance of the balance is due to a deliberate attempt on man's part to introduce an animal into a new region for purposes of his own. Well known instances of this are the introduction of the sparrow into the United States to keep down the insects that damaged

Photo: G. Hearn.

which rob the nests of the humble-bees, devouring the grubs. This illustrates part of Charles Darwin's famous linkage: the more humble-bees the more sure the pollination of the clover; but the more cats the fewer field-mice, and therefore the more humble-bees, and the more clover.

the elm trees, and of the rabbit into Australia to increase the food-supply. In both cases the results were disastrous. The sparrows certainly ate the caterpillars in the earlier part of the season, but when the corn ripened in the fields they took to eating that. The rabbits found little to check their progress, for the dingo, or wild dog, had been killed off before they came, and the carnivorous members of the marsupial order were unable to do much. The warrens increased rapidly, and in spite of all efforts to keep them down the rabbits still destroy a great deal more food than they supply, and they have turned vast areas of fruitful country into dreary desert.

Photo: G. Hearn.

BULLFINCH FEEDING ON BLACKBERRIES.

The bullfinch (*Pyrrhula pyrrhula*) may be called a partial migrant in Britain. It is marked by the rich red colour of the breast of the male, and the short stout bill suited for seed-eating.

The Story of the Mongoose.

Both man's unconscious influence and his deliberate interference are illustrated in the story of the rats and the mongooses in Jamaica, and the Antilles. There were no native rats in Jamaica, but they came there in ships from other countries, and a few always escaped to the shore. When the growing of sugar-cane began, more ships came—and more rats. They found ideal conditions in the islands. The climate suited them; there were no ground carnivores large enough to tackle them; there was plenty of cover from birds of prey; and, above all, there was abundance of delicious food to be got by simply gnawing the sugar-canes and sucking the sweet juice. It was a very Paradise for rats, and they throve and multiplied exceedingly. The cane-growers were in despair, for no ordinary measures had any appreciable effect, so they decided to import the Indian mongoose, an active little flesh-eating animal (Kipling's Riki-Tiki-Tavi), well known for its effectiveness in destroying rats and snakes.

Four or five pairs were brought in and turned loose, and the shooting of them was forbidden. They set to work merrily, and for a time all seemed to promise well. As the seasons went on the rats diminished and the mongooses increased, till in a few years there were not rats enough to feed the mongooses. These then turned their attention for a while to the native mice, called "cane-rats," and that also was useful from man's point of view.

By-and-by, however, the hungry carnivores had to seek for other prey. They robbed the hen-roosts, killed the lambs, kids, and piglings, and even the domestic dogs and cats. They pursued the game birds and ground birds till these were nearly wiped out. Many kinds of birds, several kinds of snakes, and about twenty kinds of lizards that had once been common, we are told, became very rare, and the tortoises that had once been abundant on the northern coast of the island were scarcely to be seen because of the mongoose's fondness for their eggs. Even cultivated fruits were not spared. Insects that had been kept in check by the birds, snakes and lizards, multiplied so rapidly that more than one species became a plague in the fields; in short, the whole balance of life all over the island was upset, all within a period of twenty years.

When it was realised that the mongoose was doing a great deal more harm than good, measures were taken to reduce its numbers, and in a few years a state of balance was again arrived at. It was a new balance, for the intruding mongoose had fitted into the animal community; the rats increased again, but not too far; some of the animals that had multiplied greatly remained more numerous than they had been, and a few that had been greatly reduced lost their foothold altogether.

Photo: Jaques Boyer.

GOLDEN ROSE-CHAFER ON A ROSE.

One of the most beautiful of British beetles (*Cetonia aurata*). It has an oblong, somewhat flattened body with golden wing-covers or elytra. It is fond of visiting various kinds of flowers, such as roses, and flies with its wing-covers closed, instead of widely open, as in most beetles. The grubs live in rotting wood, and the like, including ants' nests, and take a long time to turn into rose-chafers. There are said to be 1,600 species of these brilliant chafers.

The cutting down of forests is a good illustration of the way in which man's actions have interfered with the balance of nature.

Land-Skinning.

To a great extent the cutting was inevitable, for in early times a great part of the earth's surface was covered with forest, and wherever man tried to settle—for he too has won, and keeps, his foothold only by continual effort—he had to wrest from the forest a clear space for his cultivated fields, and for grazing for his domestic animals. And, as man increased in strength and his flocks and herds grew in numbers, more and more of the forest disappeared. Great tracts were cleared; marshes were drained, and more and more of the earth came under man's sway.

But in many parts of the world the cutting down of trees went too far, and brought about consequences that man, for lack of knowledge, had not been able to foresee. Where the trees on the hillsides were recklessly cut, the whole face of the land was changed. The most striking instances of this are to be found on the slopes of the Southern Alps and the Pyrenees, where once fertile valleys have become bare and sterile. The heavy rains, which used to sink into the mossy carpet of the forest, and were stored there to feed the springs, or were sucked up by the roots of the great trees, now rush down the mountain-sides in torrents, which leave behind them only a stony water-course. They carry with them earth and stones, and if the valley is a narrow one much of its fertile soil is washed into the river and borne away. If it is broader there may be less loss in this way, but we read of 70,000 acres in one district being covered all over with gravel and stones brought down from the rocky hillsides by the torrents. And where crops still grow they are at the mercy of insects, which multiply greatly now that there are no birds from the forest to keep them in check.

In the eastern United States, where pine forests have been cut down and the soil is sandy, ravines are formed very quickly, and the same thing is seen on an even larger scale in some of the Russian river valleys. What President Roosevelt called "land-skinning" is always disastrous.

We are growing wiser now. There was of necessity much cutting down of timber on the hillsides during the late war, but in most cases great old trees were spared here and there, and a protective belt was left standing to catch the water from the hill-tops, and to break the force of the winds. Side by side with the felling of the old timber, too, the planting of young trees went on, so that we need not fear the consequences which followed the reckless destruction of earlier days.

We are wiser too in other ways, for we have learnt that, if we wish to increase or extend our food supply, we shall succeed in proportion as we are willing to make a careful and patient study of Nature's methods, and to adapt ourselves to them instead of trying to impose our own. There are many instances of this in connection with the introduction of food-plants to new areas. One story, briefly told, will suffice.

In flavour and in suitability for drying, the native figs of America were much inferior to the Smyrna fig that grows in Southern Europe. Cuttings of this fig were taken to California, where the climate seemed most suitable, and were grown with success up to a certain point. The trees throve, and bore blossoms, and set fruit, but the fruit did not ripen. It fell off in an immature state.

The Story of the Smyrna Fig.

In its native conditions the Smyrna fig is always grown alongside of a wild tree, the caprifig, which bears only hard, uneatable fruits, but very abundant blossom, and the pollen of the wild fig, carried to the cultivated trees, fertilises their seeds so that the juicy fruits are able to form. Cuttings of the caprifig were taken to California and carefully grown there, and when the blossoms were open the pollen from them was transferred by hand to the fig trees. Some fruits ripened, but not nearly enough to make up for the extreme costliness of the process.

In Europe and Asia there was another life linked with the caprifig—a small wasp that laid its eggs inside the spring blossoms, and passed the winter in a resting state within the autumn flowers. It required many experiments and much study of the life-history of the wasp before it could be carried alive to America, and when that problem was solved much had still to be done. For the wasps had to be brought into contact with the fig blossoms at the right

moment when they were emerging from the caprifig. They pushed into flower after flower, dusting them with pollen off their hairy backs, as they sought for a suitable place to lay their eggs. They did not find it, for only the wild blossoms afford the right conditions, so they did no damage to the figs.

There remained the problem of keeping up the supply of wasps from year to year—they had even to have canvas shelters to protect them from the frost!—but all difficulties were finally overcome, and after *twenty years* of study and labour the cultivators' patience was rewarded and the fig industry firmly established.

XXII
LINKED LIVES

As we have seen in the previous chapter, no living creature lives by itself or for itself; each is a part of the great whole—the world of Nature. Each life is linked to countless other lives. Plant influences plant, and animal is bound to animal; moreover, the whole animal world depends for food upon plant life, though in many cases the chain between them is a long one.

The tiger in the jungle is a flesh-eater, but, indirectly, it is dependent upon the plant world, because its prey is the wild pig, and the deer, and other animals which feed on grass. The grass-eaters devour great quantities of green food. A certain amount of eating of green parts does not injure the health of the whole plant, but the pig does not stop at that, it even ploughs up the ground with its eager snout in search of roots and juicy tubers. The great grass-eaters, such as the elephant, the rhinoceros, the deer, and the cattle, are not the only enemies of the plants, for everywhere signs are to be seen of the attacks of smaller animals—the familiar "lace-work" of leaves made by gnawing caterpillars; the patterns carved on the bark of trees by bark-beetles; the curving lines that show where the leaf-miner has wandered; or the neat holes cut in the oak leaf by the leaf-cutting bee.

Photo: John J. Ward, F.E.S.

DEADLY NIGHTSHADE (*Atropa belladonna*).

A member of the potato order (*Solanaceæ*) but very poisonous. In its leaves and roots it contains an alkaloid called atropin, which forms the drug "belladonna," used in various ways in medicine. The plant is a bushy perennial herb; the fruit is a large black berry. The use of the poison to the plant is not clear.

Many plants are bound to be destroyed, but this makes room for others. The slug which thins the patch of seedlings may be helping the remaining ones to be strong, for if nothing thinned their ranks they would choke each other in their struggle for air and space to grow.

The warfare between animals and plants is not one-sided; for, as we shall afterwards see, many plants are protected from animal assaults by spines and thorns, stings and poison. Sometimes a plant gives a definite answer to the attacking animal, and curious growths appear on root or leaf or stem.

Photo: John J. Ward, F.E.S.

GALLS ON OAK-LEAVES.

"Oak-apples" of various kinds appear on leaves and twigs of oaks in response to the irritation produced by the larvæ of a gall-fly, often a species of Cynips, one of the Hymenoptera. The mother-insect deposits eggs in the plant; these hatch into larvæ, and round each larva there grows a gall. The irritation seems to be largely due to the salivary juice of the larva.

The Making of Galls.

As another example of linked lives, we wish to take the strange growths that go by the name of "galls." Strange things they are. Thus we got a huge reddish-brown gall from the root of an Alder tree growing by the river. It was larger than our fist and seemed to be made up of many swollen rootlets bound together into a queer spongy mass that yielded a little to the pressure of our fingers. It is formed when the roots of the Alder are irritated by a certain fungus; but it is one of the giant-galls.

A plant-gall is an abnormal growth induced by some intruding living creature which derives some nutritive advantage from the association. We cannot hope to get an altogether satisfactory definition, for we have already seen that the various kinds of intimate inter-relationship are not separated off from one another by hard and fast lines. The gall-making intruder can hardly be called an ordinary parasite, for the harm it does is often inappreciable, and the host often answers back in a way that favours the stranger. Yet we cannot place the true galls beside the root-tubercles on the leguminous plants like vetches and lupins, for this is a mutually beneficial internal partnership or symbiosis. The bacteria that make the root-tubercles are able in some mysterious way to fix the free nitrogen in the air mixed with the soil-water which the plants absorb. In this way they enrich the plant into which they intrude, while they in turn are perfected and supplied with carbonaceous food.

There are three kinds of animals that make galls on plants, namely, thread-worms, mites, and insects. The most important gall-making insects are gall-wasps in the order Hymenoptera and gall-flies in the order Diptera, but there are six other orders in which gall-producers occur!

But many galls are made by the action of one plant on another. Thus fungi are responsible for the galls of the Alder with which we started, for the crown-galls of fruit trees, for the warts on potatoes, for witches' brooms, and for a hundred others. Bacteria make the tubercles on the twigs of olives, as well as the root-swellings of leguminous plants, which we are not including at present. More than one kind of mistletoe is known to act as a gall-provoker, the result sometimes being the strange rayed growth called a "wood-rose." This is not a complete list of the different kinds of gall-producers, but it is comprehensive enough to show what a variety of agencies is involved.

Whenever we begin to look into galls we discover that the same stimulus usually produces the same result on the same kind of plant. Given a certain gall-wasp and an oak-tree, an oak-apple of a particular kind is formed. But different kinds of plants may answer back in different ways to the same provocation. Even more striking is the fact that the same kind of plant may produce different kinds of galls in response to different provocations, a very familiar case being the oak tree, which bears many different galls evoked by different intruders. In short, there is very marked—often two-sided—"specificity" in gall-making. This difficult word "specificity" cannot be avoided; it means something like "individuality" or "idiosyncrasy"; it means that each kind or species of living creature is itself and no other. So each kind answers back in a specific way.

There are many puzzling facts. Thus closely related species of the rose gall-wasp (Rhodites

produce very different galls, some like the well-known hairy Bedeguar, on the rose bushes, but others of a different type. On the other hand, there are cases where distantly related insects evoke very similar galls. Very strange also is the not infrequent similarity between a gall made by an insect and a gall made by a fungus. Somewhat difficult, again, is the fact that a gall may begin to form before the intruded egg of the gall-insect has hatched, although it is usually believed that the main provocation comes from the secretions of the hatched larva. Moreover, a gall may continue to grow after the supposed producers have departed.

We cannot wonder, then, that Professor Cotte and others have championed the heresy that many of the galls attributed to the larvæ of the gall-insects are really due to bacteria or some other fungi introduced by the mother when she inserts the egg. This would reduce the rôle of the gall-animal to that of a "carrier" of fungoid infection; and this may be true in some cases. It is a familiar fact in our own experience that the bite of an insect often causes a swelling and irritation that cannot be accounted for except on the theory (proved in some cases) that the puncture introduces microbes of some sort.

It is almost certain, however, that this theory would not apply to such striking galls as the oak-apples, which are produced on the tips of oak twigs by the gall-wasp, *Teras terminalis*. It is useful to think of these oak-apples, with their fine rounded shape, their large size (an average diameter of an inch), their glossy surface, and their fine colouring—yellowish to brownish, suffused with pink and red—for they give us a correct impression of the finish of workmanship that many galls exhibit. The common oak-marbles, due to *Cynips kollari*, are, perhaps, even finer, showing internally as many as eight distinct layers. For oak-galls at least it seems justifiable to say that the growth of the persistently embryonic tissue (the cambium) of the plant does not begin until the grub of the gall-wasp emerges from the egg. So far as we know, the experimental attempts that have been made to induce the formation of typical

Photo: John J. Ward, F.E.S.

BEDEGUAR-GALL OF WILD ROSE.

This interesting gall is made on roses by a gall-fly called *Rhodites rosæ*, one of the Hymenoptera, the ant-bee-wasp order. In spring, the female pricks a leaf-bud three times and deposits eggs. After a time there grows, instead of leaves, a firm, fleshy core, where the larvæ develop, and a loose mass of branched hair-like processes. The word Bedeguar means wind-brought.

galls by the injection of various fluids, such as grub-extract, have not led to any positive result; and we must confess that we do not understand why the plant should answer back in such a precise way to particular kinds of provocation.

It is customary to distinguish two main groups of galls. In one group there is some abnormal growth of an *organ* of the plant, as when a leaf splits up unexpectedly into many (fasciated) leaflets, or a branch divides into the many twigs of a witch's broom, or parts of a flower multiply and become like a bunch of green leaves. In the other group of galls there are swollen growths

Photo: G. Hearn.

BRIAR ROSE GALLS.

Galls occur in embarrassing numbers and variety, but in most cases the story is the same, that the irritation of an intruder evokes a beautifully orderly growth on the part of the plant.

and complications of *tissue*, as we see in the compact marble-galls of the oak or the hairy Bedeguar of the rose-bush. But the organ-transforming and the tissue-transforming—two kinds of bewitching—fade into one another.

The regulated growth of abnormal structure like a gall is rather striking, but a greater puzzle lies in the fact that the growth is so often useful to the gall-producer. In addition to shelter and protection there may be a development of sappy tissue, rich in nutritive reserves; there may be juicy hairs with delicate walls; there may be a water-supply and ventilation; and there may be arrangements for a spontaneous opening of the gall that sets the inmate free. Strangest of all, it seems to us, are cases in which the plant actually helps in the distribution of its gall-producing fungus. Thus the Chinese Polygonum produces, as a new kind of tissue, a loose felt-work of threads that assist in the scattering of the spores of the smut-fungus that galls it! In the case of parasitism the benefit is all on the side of the intruding organism, but there are very few cases where it can be said that the host actually plays into the hands of its unpaying boarder. Yet that is what happens in the case of many galls. Therefore, some enthusiasts have spoken, mistakenly we think, of the "altruism" of the gall-plants. Certainly the galled steed does not wince, but we cannot think that it meets the spur half-way. Perhaps the gall-growth is sometimes of value to the plant in localising the activity of the gall-producer and keeping it within bounds, but this is the only advantage we can think of.

Very often the relation between plant and animal is useful to both. The bird that robs the orchard of its cherries will drop the cherry-stones, perhaps in some spot where new trees will grow up. The squirrel that buries a store of beech-nuts for its winter food may not eat every nut. Some may remain in the ground, ready planted, and by-and-by little beech seedlings will thrust up their heads.

Flower-Birds and Bird-Flowers

Unless some striking change came about, such as has occurred in the dandelion, where seeds are formed without pollen, there are many flowering-plants that would at once come to an end if they ceased to be visited by the appropriate insects. These visitors, such as bees and butterflies, pollinate the stigmas of the flowers with fertilising golden dust from other blossoms of the same kind. This, as we have seen, is one of the most important linkages in the world, for the pollination secures that the possible seeds or ovules become real seeds that can germinate, and the cross-pollination favours both the quantity and the quality. But in exalting the importance of the insects, there has been an under-appreciation of the services of *birds*, though some cases have been known for a long

Photo: John J. Ward, F.E.S.

CONVOLVULUS HAWK-MOTH (*Sphinx convolvuli*).

One of the finest migratory British moths, usually arriving from the continent about midsummer. It has a substantial body, beautifully marked wings, strong tapering antennæ, and a long proboscis or tongue, with which it sips nectar from deep tubular flowers.

time. Insects work so well: it was not supposed that there was much need for auxiliaries. Moreover, there are no true flower-birds or bird-flowers in Europe; and when a bird was seen at a flower, as sparrows at our crocuses, it was generally supposed that it was doing more harm than good. It might pick out green-flies and other pests, but it was very apt to damage the blossoms badly. It was not realised that there are many kinds of birds that are in the main dependent for food and drink on the flowers they visit. Moreover, birds are shy creatures, not easily watched close at hand; many of the habitual flower-visitors are small, and many of them pay their visits in the late evening or early morning. So it has come about that few naturalists have realised the extent to which birds and flowers are linked together in the web of life.

But flower-visiting birds have recently found a champion in Dr. Otto Porsch, who has proved their importance up to the hilt. In warm countries there are over 1,600 different kinds of birds, such as humming-birds, and honey-eaters, sugar-birds and sun-birds, lories and "white-eyes," that habitually visit flowers for the sake of the nectar. This is at once meat and drink; it contains sugars, which furnish excellent food for strenuously exercised muscles, and more precious material besides. In most "bird-flowers" the nectar is more watery than usual, and birds require an unusually large quantity of fluid.

The habitual flower-visitors tend to be small in size, strong in the wing, able to flutter before the flowers as they drink. They usually have finely pointed bills and long tongues, often beset with slender processes forming a kind of brush. Some are, of course, more exclusively flower-birds than others, and there are some that keep very constantly to one kind of blossom. An interesting little detail is that in a few cases the male bird keeps to one kind of flower and the female to another, this depending on sex differences in the bill and tongue.

The bird-flowers, which mainly depend on birds for their pollination, belong to many

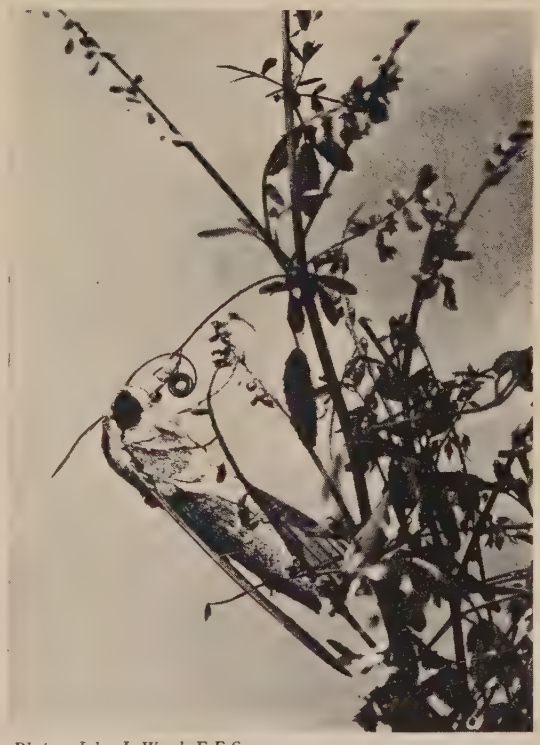

Photo: John J. Ward, F.E.S.

CONVOLVULUS HAWK-MOTH (*Sphinx convolvuli*) RE-COILING ITS LONG TONGUE. (NATURAL SIZE.)

The caterpillar feeds on the leaves of the convolvulus. When full-fed it buries itself in the ground and becomes a naked pupa. But these fine insects do not survive British winters in the open country.

different kinds, most of which are unfamiliar in Britain. We may mention the following: Fuchsia, mallows, Aloe, Brugmansia, honeysuckle, Gardenia, Tropaeolum. Their tendency is to be conspicuously coloured (including pure white), to be scentless (and, therefore, relatively unattractive to bees), to have abundant and rather fluid nectar, and to be readily get-at-able by the bill and tongue of a small bird. No doubt many butterfly-flowers show similar characters, notably bright colouring; but there are differences, such as thicker nectar and a narrower entrance to the heart of the blossom. For the proboscis of the humming-bird hawk-moth is much more delicate than the tongue of the humming-bird itself. But this must not be pressed too far; many a traveller has taken a moth for a humming-bird; and they will tend to visit similar flowers.

Porsch found in Java that over sixteen per cent. of the 170 families of flowering plants had "bird-flower" representatives in at least fifty genera. These are habitually visited by twenty-two different kinds of birds. A thoroughgoing flower-bird must either live in a place where there are suitable flowers all the year round, or it must show a seasonal migration from one floral area to another that contains similar flowers. The seasons are too sharply punctuated in Europe to admit of thoroughgoing flower-birds as residents; and there are few European summer flowers at all like those that the birds would find in their winter-quarters in the South. Therefore, we have no thoroughgoing flower-birds in Europe.

When a bird-and-blossom linkage has been established, it may work even more effectively than a bee-and-blossom linkage. For birds live longer than bees, they can work all round the year, they can begin to work while they are still young, and there are no drones. That they can carry the pollen effectively on their head-feathers admits of no doubt.

According to Porsch there are, as we have said, over 1,600 kinds of tropical and sub-tropical species that may be called "flower-birds" inasmuch as they habitually visit particular flowers on which they are in large measure dependent for their living. Altogether there are thirty-one families of birds that have representatives with the flower-visiting habit, and this does not, of course, include any of those whose stomach-contents show an appreciable percentage of small insects and spiders. For the true flower-birds are nectar-suckers. The impulse to explore flowers has doubtless arisen in part because birds are very thirsty creatures, a peculiarity to be associated with their high temperature and the intensity of their chemical changes (metabolism) going on in their bodies. Many birds that live in tropical forests are in the way of catching the drops that drip from the water-secreting structures or hydathodes of various kinds of plants, and this would naturally lead them to a closer acquaintance with flowers and to a discovery of reservoirs of watery nectar. In short, we have one more instance of the alertness that living creatures show in occupying every niche of opportunity. Every organism that discovers something new has for a time a vantage ground in the unceasing struggle with surrounding difficulties and limitations.

If a flower-visiting bird proved a successful pollinator, it is quite intelligible that individual plants that varied in the direction of accommodating this visitor would be most effectively pollinated, and would thus lead their species in a movement towards increased adaptation. Thus there are variations in the amount and character of the nectar secreted by flowers of the same kind; a variation that meant more nectar and more fluid nectar would attract most visits from birds; it would have an advantage in securing pollination; and it would gradually become the type. Such, at any rate, is the Darwinian argument, which seems to most naturalists good sense, so far as it goes.

Some of the bird-flowers are so built that the stamens are bound to dust the front of the visitor's head with pollen, and the stigma is bound in turn to be pollinated. Some have what may be called landing-stages that facilitate the bird's operations when it is stealing the nectar. In eight cases studied in detail (including Irises, Tropaeolums, and Verbenas), Porsch found that there were delicate structural peculiarities in the nectar reservoirs, specially round the margin, which made it difficult for the sugary fluid to overflow. Capillary arrangements increase the adhesiveness of the fluid to its receptacle, and wastage is thus lessened, both before and after the bird's tongue reaches down

Photo: Roland Green, F.Z.S.

RUFOUS FLAME BEARER (*Selasphorus rufus*) AT TRUMPET FLOWER.

It is now well established that many flowers are pollinated by birds, though most flowers are pollinated by insects, and many by the wind. Among the flower-birds that habitually visit bird-flowers we must give a prominent place to the beautiful hummers.

to the level of the treasure. In such adaptations certain flowers may be metaphorically called "ornithophilous" (bird-lovers), just as those that are pollinated by wind-borne pollen are called "anemophilous" (wind-lovers), and those that insects pollinate are called "entomophilous" (insect-lovers). These are awkward words for we are not prepared to think of these "loves of the plants," to use Erasmus Darwin's phrase, except in a very vague and fumbling way.

We will take next those linkages that help in food getting.

Linkages that help in Food Getting.

The common lichens which encrust damp rocks, or old walls, or trees, are different from all other plants because they are compound, that is, they are made up of two different plants, a fungus and an alga, which have united in a partnership. This union is entirely of the plant world, but there are plant-animals also. Certain plants and animals join forces and live together in a way that is helpful to both of them. A very small marine worm, about one-tenth of an inch in length, called Convoluta, lives on some sandy shores of the coast of France. It is common at Roscoff in Brittany. When it is quite young it feeds in the ordinary animal way on other animals and plants, but after a while it takes in along with its food some of the tiny, one-celled, green plants that float about in the sea. These, instead of being digested, become planted in the worm's body, where they increase in numbers till they make the little animal look quite green. The minute plant-cells make food in the plant way, and share it with their animal partner, giving it so freely, in fact, that soon the animal gives up feeding like an animal altogether, and lives entirely at its plant-partner's expense. The plant-cells find some of the material for food-making in the waste matter in the animal's body; so the partnership benefits both. The worm gets its food ready made from its green guests, while they, in their turn, find a safe shelter and a good supply for food manufacture within Convoluta's body.

Photo: W. S. Berridge, F.Z.S.

PARTNERSHIP BETWEEN A HERMIT-CRAB AND SEA-ANEMONE.

The hermit-crab (*Eupagurus*) shelters its soft tail in the shell of a whelk or buckie (*Buccinum*). On its borrowed shell the crustacean places a sea-anemone, which can sting and also serves as a mask. This is external partnership or commensalism. But the photograph also shows the protruding anterior end of a sea-worm (*Nereis fucata*), which makes another link in the chain.

The story of the Hermit-crab and the Sea-anemone shows how a partnership between two animals may be helpful to both. The Hermit-crab is a curious creature, with a soft hinder body, with no plates of armour such as the Shore-crab has, so it has to find some shelter to cover its tender tail. An empty whelk-shell makes a suitable house, and the Hermit-crab tucks its tail into this and carries it about wherever it goes. It fixes itself very firmly into the borrowed shell, by means of

Specially drawn for this work [*by Warwick Reynolds, R.S.W.*

MOTHER WEASEL, BEGINNING TO SHIFT HER OFFSPRING
TO A PLACE OF GREATER SAFETY

Photo: Edward Step.

COMMON HERMIT-CRAB (*Eupigurus bernhardus*).

The borrowed shell in this case is a large whelk or "buckie" (*Buccinum undatum*). The central pillar of the shell is gripped by the last pair of limbs borne by the soft, sensitive tail. All the body of the hermit can be withdrawn into the protecting shell, and the door is shut by the claws.

little hooks on the underside of its body, and is not easily dislodged. But Hermit-crabs often covet each other's houses, and try to drag each other from the shells. When they become too big for their houses they have to look for a larger shell, and if they cannot find an empty one they will even kill a whelk to secure its house. The Hermit-crab can retire completely into its shelter, and close the door by folding its strong pincers at the mouth of the shell.

But that is only the beginning of the story. In many cases the Hermit-crab seeks a partner. It approaches one of the Sea-anemones which are attached to the rocks of the shore-pools, and takes hold of it in one of its claws and places it on the borrowed shell on its back. There the Sea-anemone settles down, and accompanies the crab on its wanderings. How does this help the Hermit-crab? The real nature of the crab is now doubly masked, first by the whelk-shell and then by the Sea-anemone. Such concealment is one of the devices which help animals in the struggle for life. Perhaps, too, the Sea-anemone, which has stinging powers, helps a little in attack or defence. And what does the Sea-anemone gain? In ordinary conditions it remains in one spot, fixed to a stone or piece of rock, now it is carried to new hunting areas, and no doubt picks up plenty of food particles scattered by the crab.

One crab goes about with a Sea-anemone perched on each of its claws, as though it were brandishing a couple of weapons! Another partner of the Hermit-crab is a bright orange sponge, which makes a very useful ally. The sponge dissolves the borrowed shell, and itself covers and conceals the crab's body, and it is a much lighter burden for the crab to carry. It is an excellent protection, for its strong odour and the flinty needles in its flesh make it unpalatable to other animals, which soon learn to avoid it, and therefore keep away from the crab-partner too.

These sponge and sea-anemone companions are so useful to the Hermit-crab that if it loses one by accident or death, it immediately seeks

Photo: Edward Step.

HERMIT-CRAB (*Eupagurus sculpturianus*) SURROUNDED BY A SPONGE.

In this case the shell that the hermit-crab has borrowed is surrounded and masked by the growth of a sponge (*Suberites*), which has a repellent smell and is full of needles of flint.

for a new one, and induces it to settle on its back, or if it moves to a larger house it takes its partner with it.

Secondly, there are linkages which help in continuing the race. Owing to the many ways in which different lives are bound up together, the clover crop near a village depends on the number of cats in the village. If the possible seeds in the clover flowers are to become real seeds they must be reached by the golden dust or pollen from other clover heads. Humble-bees collect this golden dust, and use it to make "bee-bread" with which to feed their young ones, and as they fly from flower to flower their bodies become dusty, and so they carry the pollen from one flower to the next. But many of the young bees are destroyed, while still in the combs, by field-mice; so the fewer field-mice there are the more bees will there be to fly about the clover fields. The enemy of the mice is the cat; so the more cats there are in the village, the fewer mice will there be; the fewer mice the more humble-bees; the more humble-bees the better next year's clover crop.

Linkages that help the Race.

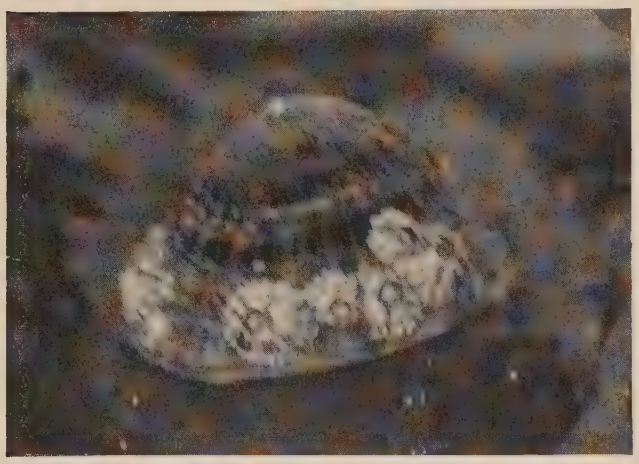

Photo: W. S. Berridge, F.Z.S.

ACORN-SHELLS OR ROCK-BARNACLES GROWING ON A LIMPET.

Here the association has no great significance. At the end of their free-swimming larval life, the rock-barnacles attach themselves to the mollusc's shell, just as they might attach themselves to a rock. Fixed head-downwards, they waft microscopic food into their mouth by means of six pairs of curl-like feet.

In the fresh-waters, too, animal is bound to animal in remarkable ways. The story of the fresh-water mussel tells of a very striking linkage. The eggs of the mussel are produced about mid-summer, but the tiny young ones are not allowed to emerge until early in the following year. They remain in a special brood-chamber inside the mussel's shell, and the mother mussel does not let them out until some fish, such as a minnow, comes close to her. Then the little pinhead-like young ones are set free, and they crowd about the minnow, and some of them manage to fix themselves on to its skin. Those which fail to do this must die. The lucky ones remain attached to the fish for some time, while great changes are taking place in their bodies, then they are ready to drop off, and start life on their own as fresh-water mussels.

The mussel is dependent on the minnow; but there is another linkage connected with it, for another fish, the Bitterling, is dependent on the mussel. The Bitterling lays its eggs by means of a long tube in the gill-chamber of the mussel, and the young fishes remain in shelter there for some time before they start their free-swimming life.

Some strange things have been discovered lately in regard to the diet of white ants or termites. Most of the termites or white ants, which are almost as interesting as true ants, no relatives of theirs, live on dry wood and equally Spartan fare. Making tunnels of earth as they go, they ascend the trees and eat the decaying branches, and everyone knows that their wood-eating habits make them very troublesome in many warm countries. They cut down the telegraph-posts, they hollow out the leg of the table, they destroy the books in the library, they destroy even the corks in the cellar.

Dry-as-dust Food.

Of recent years an interesting light has been thrown on this power of thriving on such unpromising food as sawdust by the discovery that the termites have in their food-canal numerous partner Infusorians (extraordinarily intricate and beautiful) which act as the middle-men between the particles of wood and the digestive capacity of the termites. It has been shown by Dr. L. R. Cleveland and others that the food-canal of wood-eating termites may be almost completely filled with partner Infusorians, which take into their bodies and digest practically all the wood which the termites have chewed. It is a curious contradiction that the

HOW INSECTIVOROUS BIRDS SERVE THE PLANTS

Although the sparrow levies heavy toll on the young green shoots in the garden, by linking vegetarian tastes with an equally ready appreciation of insect diet he more than compensates the plants for any damage he does. Attracted, like the sparrow, to the young shoots, the cockchafer (*Melolontha vulgaris*) periodically breeds in such numbers as to become a far greater source of danger than the ravages of birds. The sparrow attacks the pest, thus becoming a useful ally of the plant. One pair of these much maligned birds have been known to destroy as many as 700 cockchafers to supply their family.

Photo: Jaques Boyer.

Female cockchafer laying eggs on the ground.

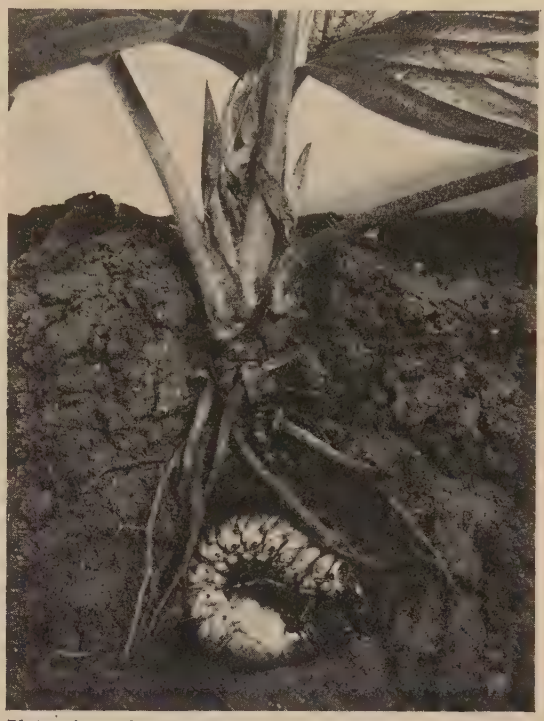

Photo: Jaques Boyer.

The larva of cockchafer attacking roots of strawberry plant.

Photo: Jaques Boyer.

Adult cockchafers feeding on the young buds of a cherry tree.

Photo: Albert Henry Willford.

The enterprising house sparrow devours the cockchafers.

THE DEATH-WATCH BEETLE AND ITS WORK OF DESTRUCTION

Photo: Prof. Maxwell-Lefroy, M.A.

The common death-watch (*Anobium domesticum*) is a small dark brown beetle. The photograph shows it highly magnified.

Photo: John J. Ward, F.E.S.

Most of the damage is done by the grubs, two of which are shown in their burrows in a piece of wood, marked +

Photo: John J. Ward, F.E.S.

Wooden gas-fitting block riddled with holes by the burrowing of the death-watch larvæ, and beginning to crumble.

Photo: John J. Ward, F.E.S.

Gas-fitting block almost reduced to powder. The tiny beetle is shown on the white square. Its length is about a sixth of an inch.

normal diet of termites is wood; yet they cannot get any good out of this unless the partner Protozoa digest it for them.

It is easy by raising the temperature to kill all the partners without injuring the insects, and in these cases the termites die of starvation even when they chew plenty of wood. But they will escape from the very jaws of death if they be re-stocked with partners!

Mr. Cleveland has recently found out how the microscopic Infusorians ingest the particles of wood. These adhere to the posterior, possibly sticky, surface of the little body, which then becomes indimpled into a tiny cup. The cavity of the cup then closes up, and the particles that were outside are now inside. Digestion follows.

One of Dr. Cleveland's experiments is very striking. He got colonies of two kinds of termites to thrive for eighteen months on pure cotton cellulose in the form of Whatman filter paper! Everything that happened in colonies fed on wood occurred in the self-same way in the colonies that fed on filter paper. Thousands of eggs were laid, and everything went just as usual. "In some cellulose-fed artificial colonies which contained ten adult individuals in the beginning, more than two hundred half-grown individuals are now present. Thus the weight of these colonies has increased more than forty times on a diet of cellulose." Now increase of living matter means increase of protein material, and the question arises whether the termites, with the help of their partner Infusorians, are able to transform carbohydrates into proteins, which are nitrogenous carbon compounds, or whether they are able in some way to fix the atmospheric nitrogen, as is well known to occur in peas and clovers which have partner bacteria in their root tubercles.

There are complicated castes in a termite community. Thus, besides the reproductive males and females, there are permanently juvenile workers — imperfectly developed non-reproductive individuals. Among ants and bees the workers are arrested females; among termites the workers are arrested individuals of both sexes. But besides the workers there are soldiers, which are marked by their large jaws. Now, owing to their large jaws, the soldiers cannot chew wood except when they are quite young. How, then, do they continue to live? The answer Dr. Cleveland gives is that they feed on the partially digested woody material which has passed through the food-canal of the ordinary wood-chewers. The soldiers harbour partner Infusorians just as the workers do. But besides soldiers the colony includes two

Photo: Reginald H. Malby.

APHIDS OR GREEN-FLIES SMOTHERING THE PLANT.

The aphids, green-flies, or plant-lice, for they get many names, belong to the order of bugs or Rhynchota. They pierce the plant with their sharp stilets, and then suck up the sap. The overflow is called honey-dew. They weaken the plants; they smother it with their overflow; they make it easier for fungi to settle.

other types of individual which show after early life a degeneration of the jaw muscles. They are *reserve* males and females. They are unable to chew wood, and they have no partner Protozoa. They seem to be fed by freewill offerings of salivary juice contributed by the workers!

Honey-dew.

We used to know an avenue of lime trees in a country town where the ladies were wont to put up their sunshades because of the drip of honey-dew. Often the pavement was wet with the sweet drops, and while it is said that the greater part of true dew is water-vapour that condenses as it *rises* from the ground, there is no doubt that honey-dew falls. What is it?

Photo: G. H. Hewison.

PROBOSCIS OF APHIS.

As in other members of the order of bugs (*Rhynchota*), there is in Aphids a mobile, jointed proboscis or beak, which is inserted into the skin of the plant. Inside the proboscis there are four movable bristles or setæ, finer than horse-hairs and very sharp. They probe the wound. The suction is due to the muscular pharynx.

The old naturalists said it fell from heaven, and in modern times it has often been regarded as an exudation of surplus from the sugar factories of the leaves. But the origin of honey-dew is as an overflow from the food-canal of green-flies and related insects, which tap the plant's stores with steady persistence. The insect inserts its piercing needles into the sappy tissue, the pharynx acts as a suction-pump, there is a slight digestive change in the food-canal, and what is not absorbed is passed out as glucose. Many green-flies or Aphides have two siphons or "honey-tubes" opening from the general cavity of the body to the exterior on the dorsal surface posteriorly; but, in spite of many statements to the contrary, these have nothing to do with honey-dew. They secrete oil-like globules of a waxy substance which has a separate origin and use.

The honey-dew is an overflow of sugary fluid from the food-canal; and Dr. Büsgen, who has written a book on honey-dew, says that he has observed a single Aphis giving out in twenty-four hours no fewer than forty-eight drops, each about a millimeter in diameter.

While this is the natural history of honey-dew properly so-called, it may be noted that some plants secrete surplus sugar on their leaves, and sometimes in special overflow surfaces called extra-floral nectaries, which are comparable to the ordinary nectaries found in the flowers.

All the Aphides' tapping of the plant's sugary resources must be detrimental, and Büsgen calculated for one bad case of "blight," as the infestation is often called, that the green-flies were removing about a sixth of the total amount of carbohydrate material required to build up and sustain the whole foliage. This means a serious drain on the plant. But there are other disadvantages, for the honey-dew chokes the pores of the leaves and also affords a suitable culture medium for the spores of injurious rusts and moulds that may proceed to attack the plant. This reminds one that the term "honey-dew" is also applied to the peculiar condition that is brought about when the flowers of rye are attacked by the fungus called ergot—the source of a well-known drug. The spores that develop in the flower of rye float in a "honey-dew" fluid produced by the fungus, and this attracts insects which spread the infection from plant to plant.

But the presence of the ordinary green-fly honey-dew on the plant has other implications. It attracts ants whose presence in moderate numbers may be no bad thing. As is well known, there are some kinds of ants that have learned to regularise the honey-dew business by making the Aphides their cows, *vaccae formicarum*, as Linnæus said. They may be said to shepherd the green-flies on the branches; they sometimes

Photo : G. H. Hewison.

THE THISTLE APHIS (GREATLY MAGNIFIED), AND ONE OF ITS ENEMIES, THE LACEWING FLY.

For many generations the Aphids are all wingless females, which produce young ones like themselves. This sequence may be interrupted by the appearance of winged individuals, a few of which may be males. Later on in the season there is a production of eggs which require to be fertilised. These fertilised eggs hatch out the following spring.

make folds; they stroke the cows with their antennæ and lick them with their tongue, just as if they were milking them! In certain cases, when autumn comes, the ants take some of the Aphides down into the underground nest and there the cows lay eggs!

The ants take care of these eggs, and the young Aphides which develop from them are transported in spring on to a suitable plant. A remarkable feature is that some of the Aphides are in the habit of migrating from one kind of plant to another, as from apple-tree to grass, and the ants have actually been seen, as it were, anticipating this migration. In any case they have been seen carrying the Aphides to the new haunt, just like the Swiss farmers shifting their cattle from "Alp" to valley. When we think of these linkages, and of others, such as the multitudes of insects that feed on Aphides, we begin to hear the whir of wheels within wheels.

A strange chapter, still rather a dark one, concerns the fact that many Aphides contain

Photo : Jaques Boyer.

The larva of the golden lacewing fly (*Chrysops vulgaris*) is about half an inch long. It has strong sickle-shaped jaws, with which it pierces and kills its small booty of Aphids.

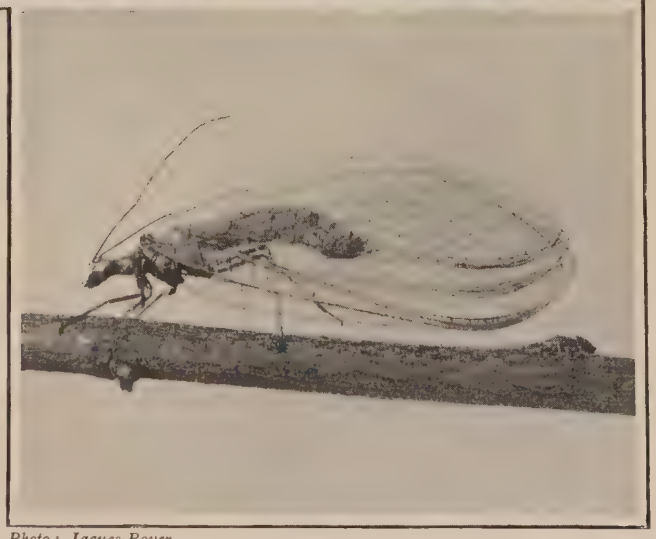

Photo : Jaques Boyer.

THE LACEWING FLY.

It is a delicately beautiful distant relative of the dragon-fly. The four transparent, lace-like wings rest in roof-like fashion over the elongated body. The colour of the wings and body is pale green; the eyes are like bright gold. The eggs of this elegant insect are suspended on longish threads from beneath a leaf.

Photo: John J. Ward, F.E.S.

BROWN RAT, SEEN AT ITS BURROW, WHICH IT HAS MADE THROUGH A GRAVEL PATH IN A GARDEN.

The brown rat (*Mus norvegicus* or *decumanus*) began to appear in Britain about 1730, and soon outnumbered its predecessor, the black rat (*Mus rattus*), which arrived during the fifteenth century. The original home of the brown rat may have been Mongolia; it is certain that it came from the East. In India, where plague is common among rats, it has become a terrible menace, through its parasite, the rat-flea, shown on the opposite page.

numerous peculiar micro-organisms which seem to be useful partners or symbions. In certain species the whole history of these yeast-like partners (forming the symbiotic organ or "mycetom") has been followed from the egg to the adult Aphis. A remarkable feature is that they never seem to become too numerous, and another point in favour of the partnership theory is that the microbes secrete digestive ferments.

Related to Aphides there are minute insects called Psyllids ("jumping plant-lice"), and some of them form honey-dew which may be abundant enough to drip from the trees. As in Aphides this seems to be a surplus from the food-canal, and it is said to have "a good clean flavour." It is chiefly formed in the nymph stage of the insect's life-history, just before the adult characters develop. But some of the Psyllids secrete a solid substance in the form of a protective scale like half of a miniature cockle shell. It is fastened to a leaf by a hinge and forms one of the kinds of manna, e.g., on Australian gum-trees. But every wilderness has its own manna!

Profitable Partnerships.

Many are the devices for securing a foothold in the stress of life, and among these are linkages between plant and animal, or animal and animal. The coarse hair of the Tree-Sloth is often covered with minute, single-celled, green plants, so that as the animal hangs down from the branch of a tree its shaggy coat looks like a mass of foliage. There are many cases of strange partnerships between quite different animals. A little burrowing owl is tolerated as a guest in the home of the North American Prairie-dog, while the New Zealand Lizard shares its hole with the big-billed Puffin. In the sea many animals give shelter to non-paying guests, which must not be thought of as parasites, for they do not prey upon their hosts, they merely seek shelter, and perhaps a few of the crumbs which fall from the other's table. The Sea-cucumber is a sluggish, cucumber-shaped animal (belonging to the same group as the Starfishes and Sea-urchins), through whose body a current of water continually passes. Fierasfer is a very small fish, which is only comfortable where there is actively moving water and also darkness. So Fierasfer

enters the body of the Sea-cucumber. It does no harm to its host, and comes out from time to time to forage for its own food. It simply lies peaceably inside an annex of the Sea-cucumber's food-canal, where it can avoid the light it dislikes, and yet get the water-current it must have. Sometimes the little fish seeks shelter instead in some shell-fish, such as the mussel. If it remains between the mussel's breathing gills it is quite safe, but if it strays between the shell and the soft shell-making layer or " mantle " below, it may cause irritation. An intruding fish in this position may be dealt with by having a coating of mother-of-pearl deposited over it !

The jelly-fish, that floats like a delicate, transparent umbrella in the water, is well-protected from other animals. It is too slippery to be an inviting mouthful, and, moreover, it is well-armed, for its stinging threads are deadly weapons. Some little fishes, however, do not suffer from these stings, so they make a habit of keeping near the jelly-fish, and if an enemy approaches they dart underneath the umbrella for safety. In the same way, as many as ten little fishes can shelter under a " Portuguese Man-of-War," a drifting colony of transformed swimming-bells, with numerous stinging tentacles. The fishes get more than protection, for their living shelter stings to death many more animals than it requires for its own food, so the little guests can pick up many morsels.

As the powerful shark races through the water it is often closely accompanied by a much smaller fish, called the pilot-fish. This fish snaps up the crumbs the shark lets fall, and also gains security from possible enemies, because most of them are afraid to come too near its formidable companion. The sucker fishes go a step further. Instead of swimming by their own efforts they actually attach themselves to whales or turtles, or even ships, and so are carried from one hunting-ground to another.

Non-paying Boarders.

In these associations the guests do no damage to their tolerant hosts, but some animals attach themselves to others, or even live within their bodies, and draw their food from them. Such hangers-on are known as parasites. Like other animals, they want food and shelter, and they get them by becoming uninvited guests on or in some larger animal ; but, as a rule, the animals with this thievish habit sink down to a lower level of life than their fellows. For example, a certain crustacean, called Sacculina, is in its young stages very like many another young crustacean, an active little creature, able to swim about in the sea by means of its three pairs of limbs. But, after a time, Sacculina gives up its free-swimming life, and fixes itself on to a young crab. It loses the limbs and the eye, and most of the other things it had when it was a promising young swimmer, till at last it is a mere oval sac, which protrudes on the under side of the crab's

Photo : John J. Ward, F.E.S.

RAT-FLEA, CARRIER OF THE PLAGUE.

The rat-flea (*Pulex cheopis*) differs only in minute details from the common flea (*Pulex irritans*). It occurs all over the world where rats are found, but it does not always carry the plague microbe (*Bacillus pestis*). When an infected flea, carrying the bacillus, leaves the plague-smitten rat and bites man, the result is bubonic plague. This is not contagious until it develops into pneumonic plague, which is apt to become an epidemic.

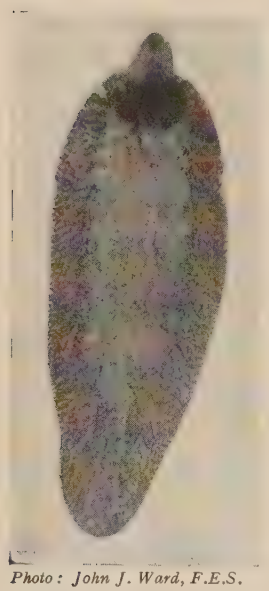

Photo: John J. Ward, F.E.S.

LIVER FLUKE (*Distomum hepaticum*), ENLARGED.

The common liver fluke is flat, oval, and leaf-like, about an inch in length by half an inch across the widest part. It is reddish-brown to greyish-yellow in colour, but it is often stained greenish by the bile. It lives in the liver and bile-ducts of the sheep, and occasionally in some other mammal. It feeds on blood.

tail. It draws its food through little tubes from the crab's body. Almost the only power it has left is that of producing eggs. In other ways it has sunk into a lower state, the penalty it pays for the life of ease it has adopted.

Different Animals with a Thief in Common.

Since there are these thievish creatures, it often happens that two or more very different animals are linked together by having a common thief or parasite.

The liver-fluke is a leaf-like creature about an inch long, which lives as a parasite within the sheep's liver, and causes the disease called liver-rot. It produces many thousands of eggs, which pass out of the sheep's body. If they fall on dry ground they soon die; but if they reach a pool of water they have a chance of continuing their life. Minute larvæ come out of the eggs, and swim about in the water. The first danger is past, they have reached the water. But now they have a new need. They will perish unless they meet a water-snail within eight hours. Immediately the larval fluke touches one of these water-snails, so common in pools, it enters its body by the breathing hole. Inside the snail the fluke-larva gives rise to other larvæ of a different type, and these give rise to more like themselves, which, in their turn, give rise to a third kind. This third kind returns to the water, but only for a short time. Soon they wriggle up the grasses at the edge of the pool, and settle down as tiny white specks on the blades. If a sheep comes along and eats this grass, the young liver-flukes are swallowed too, the sheep's liver becomes infected, and the story is complete. But, luckily for the sheep-farmer, there are many things which may break the chain. The eggs may never reach the water, or the larvæ may fail to find a water-snail, or a pied wagtail may snap up the snail, or the sun may shrivel up the white spots before a sheep swallows the blade of grass. Thus there are a great many chances against the completion of the liver-fluke's story.

We have given Darwin's well known illustration of linkages—the connection between cats and the clover crop. But there are many more instances, and these we might put in the form of Natural History conundrums.

What is the connection between squirrels and a good harvest?

Squirrels are often shot down because they nip the tops of young fir trees, and peel the bark from the larches, but they also eat the eggs and the young of wood-pigeons. Now, as wood-pigeons eat surprising quantities of grain, the farmer ought to consider their enemy, the squirrel, his friend.

What is the connection between cats and the plague in India?

The dreadful disease of plague is common among rats in India. Rat-fleas bite the rats and get the disease germs. When the rat dies the fleas always leave the body, and then they

Photo: F. W. Bond.

POND-SNAIL, (*Limnæa stagnalis*),

belonging to the freshwater family Limnæidæ, various members of which harbour the young stages of the liver-fluke and other flukes. Although these snails can breathe for many weeks under water, notably under ice, they usually come to the surface at frequent intervals to fill their mantle cavity with air. The nearly related *Limnæa truncatula* is the only species in Britain that is effectively parasitised by the larval liver-fluke.

Photo : F. Martin Duncan, F.R.M.S., F.Z.S.

THE SEA-CUCUMBER.

Sea-cucumbers or Holothurians belong to the group of Echinoderms or prickly skinned animals. They are distant relatives of sea-urchins and starfishes. The body is somewhat cucumber-like or sausage-like, bearing at one end the mouth and a wreath of five or more branched tentacles. Through the body passes a continuous stream of water which attracts the small fish, Fierasfer, to enter and live in comfort in the dark interior.

may bite a human being and infect him with plague. So the more cats there are to kill the rats, the less danger is there of an outbreak of plague.

What is the connection between trout and successful fruit-farms ?

Trout were introduced into the rivers of Tasmania, which is a great fruit-growing country, and the production of fruit was lessened. Why? Because trout eat the aquatic larvæ of dragonflies, which live as adults on scale-insects and other fruit pests.

What is the connection between little fishes and the decline of Greece ?

It has been suggested that Greece declined because of the introduction of malarial fever, which till quite recently was supposed to be caused by bad air rising from swamps. Now we know that malaria is due to a parasite, and that this parasite spends part of its life in man and part in a mosquito. The mosquito is as necessary to its story as the water-snail to the liver-fluke's. The mosquito bites a person suffering from malaria, and so receives the parasite, which continues its life-history within the insect's body. Some time later the mosquito bites another human being, who then becomes infected in his turn. When this was discovered, means were sought to reduce the numbers of the insects, and so combat the fever. Little fishes introduced into the ponds where the mosquitos breed were found to devour enormous numbers of the insect larvæ. So, as in the old story of " for lack of a nail the battle was lost," the chain of linkages is built up.

XXIII
THE QUEST FOR FOOD
VEGETARIAN ANIMALS

LIVING is activity, and that means expending energy. But living creatures cannot make any new energy (or power of doing work); they can only change the energy from one form to another. Therefore if the living creatures are active, they must sooner or later take in food, just as engines must take in fuel of some sort. Feeding means stoking the body, and just as there are engines that burn coal and others that burn wood, and others that

burn oil, and alcohol, so there is an interesting variety of foods, and we shall begin with the food of animals.

The Variety of Diets.

Ordinary green plants are able to use the energy of the sunlight to build up food-materials, like sugar, from carbonic acid gas and soil-water. There are a few green animals, like the Green Bell-Animalcule (*Vorticella viridis*), which have gained possession of chlorophyll, the characteristic green pigment of plants, and thus are able to feed as green plants feed. But this is very exceptional. There are other green animals, like the Green Hydra and the Green Sea-Anemone, which are green because they have entered into partnership with microscopic greenish plants, and they are able to draw part of their food-supplies from their partners. We shall return to these, but let us leave them out of account at present, for the big fact is that animals depend for their food: (1) on other animals; or (2) on plants; (3) or on what animals produce, e.g., honey; or (4) on what plants produce, e.g., manna; or (5) on fragments or portions of living animals and plants; or (6) on the particles into which dead bodies break up. Already we see that it is not a simple question: "How do animals get their food?" It will not be enough to give as answer—"Carnivorous, Herbivorous, Omnivorous."

Long before land-plants emerged there was a great growth of seaweeds in the shallow shore-waters. That is why we begin with a diet of seaweeds, for it must be one of the oldest of diets. When we examine the tangle at low tide we find many animals browsing on it. There is, for instance, the extraordinarily beautiful Pellucid Limpet (*Helcion pellucidum*), with lovely blue lines on an almost transparent conical shell of the same brownish colour as the oar-weed on which it feeds. It bites holes through the weed with the flexible file (or radula) in its mouth, and in the course of time shreds are broken off, and the great frond, sometimes six feet long, is reduced to tatters. We may mention that there is a variety of the Pellucid Limpet, with a stronger shell and no blue lines, that burrows among the anchoring "roots" of the oar-weed, and so weakens them that a heavy storm may tear off the big plant and hurl it on the beach.

Seaweed-Eaters.

Further up on the shore we may find the leisurely Sea-Hare (Aplysia) nibbling at the green Sea-Lettuce (Ulva) and cutting it up into tiny pieces. The Chitons, with their eight-jointed armour, and the common limpets are good examples of seaweed-eaters, but let us take something bigger.

The Story of the Turtle.

The Edible Turtle (*Chelone mydas*) is a reptile that has gone back from the land to the sea, as it proves by coming in from the water to suitable sandy beaches in order to lay its eggs. It is about three feet long, a thoroughgoing vegetarian, and it cannot stay long outside the area where the seaweeds grow. Unlike the carnivorous turtles, such as the Loggerhead and the Leathery Turtle, it would starve in the open sea. It is very fond of the sea-grass (Zostera), a flowering plant that grows in salt water, and Dr. Gadow quotes a curious statement. When they have eaten their fill they are said to chop off more of these plants, and "roll them, together with the adherent mud, into balls of the size of a man's head, and these balls, receding with the tide, are followed by the turtles"! The edible turtles are found in the Atlantic, Pacific, and Indian Oceans, and are greatly valued for the sake of the palatable flesh. There are many different ways of catching them. If one is seen crawling along the bottom, a fisherman with a rope round his waist may dive upon it and be hauled up by his companions, bringing his captured turtle with him. Or one may be harpooned as it floats, sound asleep, on the surface. Or a string may be tied to the tail of the Sucking-Fish (Echeneis), which seeks shelter underneath the turtle, and fixes itself so firmly that the reptile can be gently raised to the surface or within reachable distance.

When the females come ashore to lay their eggs in the sand, advantage is taken of this to capture large numbers at a time, and it is the practice to turn them upside down by means of poles, so that they cannot escape to the sea before the boatload is secured. There is reference to this in the phrase "turned turtle," which is used when a ship turns upside down.

A first cousin of the Edible Turtle is the rather smaller Hawksbill (*Chelone imbricata*), which ranges over all warm seas. Although a very near relative, it is strictly carnivorous, feeding

Photo: John J. Ward, F.E.S.

GARDEN SNAILS FEEDING ON RHUBARB LEAVES.

Snails may be taken as good examples of leaf-eaters. Most of the land species, like the garden snails (*Helix aspersa*) here shown, are strictly vegetarian, and eat all sorts of plants that are not naturally protected in some way. They usually turn away from leaves that are very acid, like sorrel, or contain strong-smelling oil, or are full of small crystals, like cuckoo-pint.

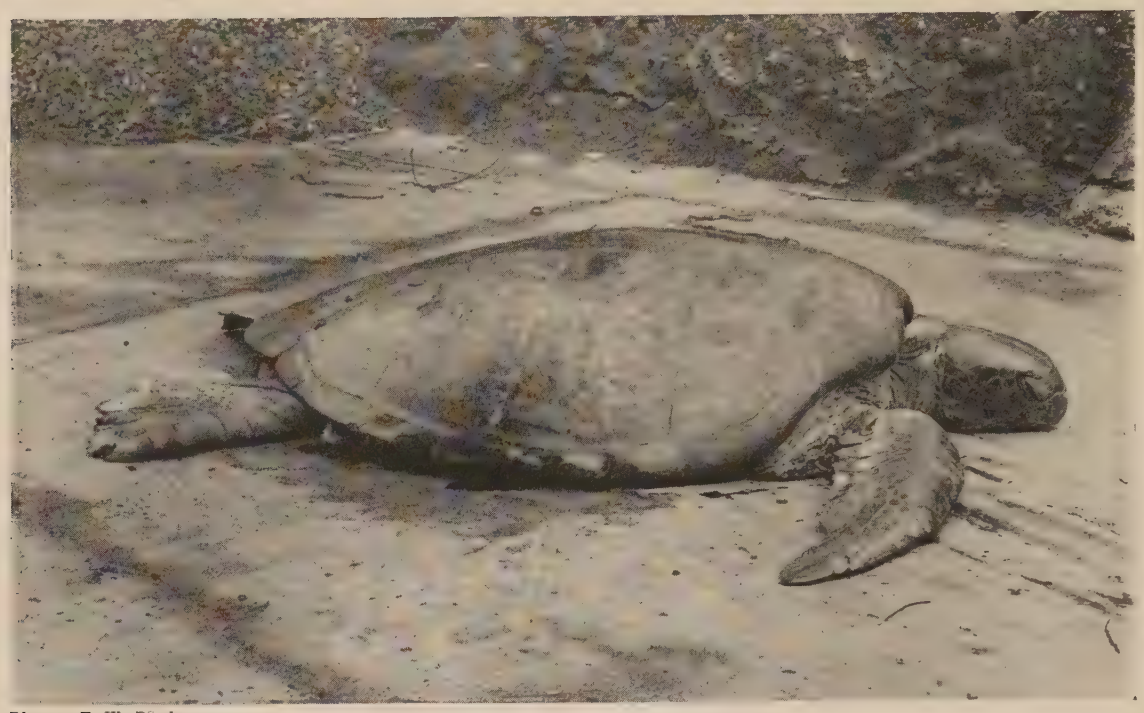

Photo: F. W. Bond.

EDIBLE GREEN TURTLE (*Chelone mydas*).

This turtle has an almost smooth shell, which may be nearly four feet long. Those with a length of three feet weigh about three hundredweight. Their home is in the Atlantic, Pacific, and Indian Oceans, and being strictly vegetarian they do not habitually go far out to sea. They browse among the seaweed, and also eat large quantities of *Zostera marina*, or sea-grass.

on fishes and molluscs, and its flesh is not edible. It is persecuted for the sake of the beautiful horny scales of " tortoiseshell," which can be bent into various shapes if first heated in oil. There are records of the Hawksbill mother returning year after year to the same place in order to deposit the eggs, and the same " homing " has also been noticed in the Edible Turtle.

The Story of the Sea-lizard.

One of the most remarkable seaweed-eaters is the marine lizard (*Amblyrhynchus cristatus*), which frequents the rocky shores of Galapagos Islands, and has acquired the habit of diving down among the seaweed for the kinds it likes best. It attains a length of four feet, and is sluggish on land. On the voyage of the " Beagle," Darwin was much interested in this animal, and noticed some very interesting features. " When in the water this lizard swims with perfect ease and quickness by a serpentine movement of its body and flattened tail, the legs being motionless and closely collapsed on its sides. A seaman on board sank one, with a heavy weight attached, thinking thus to kill it directly; but when, an hour afterwards, he drew up the line, it was quite active. Their limbs and strong claws are admirably adapted for crawling over the rugged crags and fissures of lava, which everywhere form the coast. In such situations, a group of six or seven of these hideous reptiles may oftentimes be seen on the black rocks, a few feet above the surf, basking in the sun with outstretched legs."

One of the peculiarities Darwin noticed is puzzling. The lizard is, of course, a lung-breather, and when it dives it must depend on the store of oxygen in its lungs and blood. Yet it takes to the water voluntarily and habitually. But it will not be chivvied into doing so. What puzzled Darwin was that when the lizards were driven on to a little point overhanging the sea, they would sooner allow a person to catch hold of their tails than jump into the water. When he threw one in, it returned at once. " I several times caught this same lizard by driving it down to a point, and though possessed of such perfect powers of diving and swimming, nothing would induce it to enter the water; and as often as I threw it in it returned." Darwin's explanation

of this curious behaviour was that the lizard has no enemies on land, whereas there are numerous hungry sharks in the sea. "Hence, probably, urged by a fixed and hereditary instinct that the shore is its place of safety, whatever the emergency may be, it there takes refuge." It must be remembered that the lizard's marine excursions are probably of comparatively recent origin. In support of this view there is an interesting piece of evidence, namely, that the marine lizard has a "double," a near relative, that keeps to the land.

We must describe this terrestrial cousin a little, for though it takes us away from the seaweed, it lets us into a secret. Darwin called it just a kind of Amblyrhynchus; its technical name nowadays is *Conolophus subcristatus*; but everyone is agreed that it is nearly related to the marine form, and that it represents the old-fashioned way of living. When Darwin visited James Island, one of the Galapagos group, there were such crowds of these lizards that "we could not for some time find a spot free from their burrows on which to pitch our single tent." They are sluggish animals, that crawl slowly along with their tails and bellies dragging on the ground. They often stop and doze for a minute or two. In making the burrow in the soft volcanic earth one of these quaint lizards works first the legs on one side of its body and then those on the other side, in regular alternation. Darwin writes: "I watched one for a long time, till half its body was buried; I then walked up and pulled it by the tail; at this it was greatly astonished, and soon shuffled up to see what was the matter; and then stared me in the face, as much as to say 'What made you pull my tail?'"

The land kind differs from the sea kind in having the tail rounded, not flattened, and in not having webbed toes. It feeds on succulent cactus, on the leaves of acacia bushes, and on acid berries that fall from trees. But the most interesting point is just this, that of two near relatives, living in a confined part of the world, one has become a burrower and a cactus-eater and the other a swimmer and a seaweed-eater.

Photo: W. S. Berridge, F.Z.S.

HAWKSBILL TURTLE (*Chelone imbricata*).

This marine turtle is carnivorous, unlike the green turtle. The largest shell on record is thirty-four inches long. Being independent of the seaweed, they go far out to sea, and feed on fishes and molluscs. Their flesh is not eaten, but the horny shields furnish the "tortoise-shell" of commerce. Like the edible turtle, they lay eggs on sandy beaches, and often go back year after year to the same island.

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GIANT LIZARD ON A GALAPAGOS ROCK AMIDST THE WAVES.

The giant lizard (*Amblyrhynchus cristatus*) is the only lizard that ventures into the sea. It is confined to the Galapagos Islands. It reaches a length of four feet and has very strong claws, enabling it to hold firmly to the rocks when it is browsing on the seaweed. It is one of the Iguanas, and has a near relative, Conolophus, which keeps strictly to the interior of certain of the Galapagos Islands, feeding on the fruits of the prickly pear and other cactuses.

The meaning of it all is that the conditions of life are difficult for them both, and were difficult for the common ancestors from which both are descended. Two very different solutions have been found, and one of these solutions was unique. For there is only one lizard that dives into the sea and swims about, and there is only one lizard that eats seaweed. The secret is this, that when animals are hard pressed they look about eagerly for any vacant corner or for any way of life that is not being tried. The realm of life is crowded with "shifts for a living."

Sea-Cows.

On the Atlantic shores of Africa and America (as far north as Florida) there live very strange, old-fashioned mammals, called manatees. Black in colour, thick-skinned, with flipper-like fore limbs and no hind limbs, they are bundles of peculiarities. Thus the upper lip is split into two, and the bristly halves play on one another like the points of a pair of forceps. With these they grip seaweeds, along with which there is often swallowed a good deal of sand. The manatees sometimes go up rivers, and then they feed on fresh-water plants, like water-lilies. There are numerous back teeth for milling the tough and gritty food, and as these get worn away, their place is taken by others.

Related to the Manatee is the Dugong of the Indian Ocean and Australian Seas, the only other living "sea-cow" (or Sirenian). It is the basis of *some* of the mermaid stories, for the young one is held to the breast with one of the flippers. But this would not explain European "mermaids," would it? The dugong is a seaweed-eater, but its back teeth are few in number and soon fall out. They are not of much importance in chewing, and their place is taken by horny plates.

There used to be a third member of this strange old-fashioned order, namely Steller's Sea-Cow, which frequented the Behring Strait. The last one was seen in 1854, for the interesting creature was exterminated by sailors. It was much bigger than its living relatives, for it reached a length of 20–30 feet; but it also was a seaweed-eater. There were no teeth at all except two vestiges on the upper jaw, but there was a very strong horny palate against which the seaweeds were rubbed to shreds. It is interesting to see in these three nearly related animals three different ways of eating seaweeds.

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THE GIANT LIZARD (*Amblyrhynchus cristatus*) OF THE GALAPAGOS ISLANDS.

Unique in its habit of swimming out into the sea and eating seaweed from the rocks, it seems to dislike boisterous surf, and prefers to keep to quiet corners. Mr. Beebe saw some that seemed to be four feet long, but the largest one captured measured forty-one inches.

Photo: W. S. Berridge, F.Z.S.

TWO-FINGERED TREE-SLOTH (*Cholœpus didactylus*).

This old-fashioned arboreal mammal lives in South American forests. As is seen in the photograph, there are only two fingers; but there are three toes. The hair is long and shaggy, and bears minute Algæ, which give it a greenish colour. Thus the animal is inconspicuous on branches covered with hair-like lichen. It creeps along back downwards.

§ 2

Leaf-Eaters.

Long before there were grassy meadows there were trees, and we think that leaf-eaters should be ranked as the second great group of vegetarian animals. The old-fashioned giraffe, whose head may be sixteen feet above the ground, lives in grassy steppes in Africa, but it feeds on the leaves and sappy twigs of small acacia trees, which it grips with its long and strong tongue. It is interesting to notice that the very long neck has seven backbone-bodies (or vertebræ), just as we have, and just as the almost neckless whales have. In all mammals save four this number seven holds for the neck, whether it be long or short. One naturally thinks of the giraffe as a very conspicuous animal, it is so huge and spotty. But while it is conspicuous when moving about (its name means "one who walks swiftly"), it is well concealed when among the trees. The spots seem to help in obliterating its vast bulk. Sir Samuel Baker wrote: "I have frequently been mistaken when remarking some particular dead tree stem at a distance that appeared like a decayed relic of the forest, until upon nearer approach I have been struck by the peculiar inclination of the trunk; suddenly it has started into movement and disappeared." The giraffe is a nervous creature, and its long neck is probably of importance, like that of the ostrich, for keeping a look-out for such enemies as lions and leopards.

Also leaf-cutters and also very old-fashioned are the tree-sloths of the South American forests. They move slowly about, hanging with the long curved claws of their hands and feet to the under-side of the branches. In this posture, back downwards, they also rest and sleep. They are very awkward on the ground, but they never come down if they can help it; they are even more arboreal than monkeys.

There is something antediluvian about these tree-sloths, and we know that they are survivors from very ancient days. They are slow in moving, slow in eating, slow in dying. Their rough, shaggy hair is like the "vegetable horse-hair" of some of the perched plants of the forest, and it has a strange greenish colour. There is a minute green Alga that grows on the rough hair of the Sloth, just as some of its allies grow on rocks and on the stems of trees. We all know the green dust which comes off on our clothes when we rub against a beech tree in damp weather.

The Tree-Sloth is seen at a great disadvantage on the ground, and it rarely seems to have any idea of resenting treatment. Mr. Oswald writes that the Mexican species surrenders at discretion to all his enemies, great or small. "He permits

you to lift his claw, but drops it as soon as you withdraw your hand. If you prod him he breaks forth in a moan that seems to express a lament over the painfulness of earthly affairs in general rather than any resentment of your particular act. If a dog bites him, or if you offer him a tit-bit after a prolonged fast, and snatch it away from his very jaws, he will slowly turn his head, and then, as if the significance of the indignity were gradually dawning upon his mind, he breaks forth into crescendo grunts, resembling at once the whir of a buzz-saw and the droning hum of a bee-hive." In the " Riverside Natural History " (1888), from which we have quoted these lively sentences, the forest cry of the Tree-Sloth is described as " a long drawn, tremulous moan, not unlike the wail of the whip-poor-will or a lugubrious variation of a watch-dog's yelp."

There are different kinds of sloths, two-toed and three-toed, and each kind has its favourite diet of leaves. Thus the Mexican two-toed sloth keeps almost wholly to leathery leaves with a milky juice, while the three-toed kind is fondest of the leaves of a tree called Cecropia. When one native reproaches another for idleness—the pot calling the kettle black—he says, " You beast of the Cecropia tree." But the important point is that there is a tendency among many animals to become " specialists " in what they eat, whereas others—take the otter for instance—have a very long bill-of-fare. Both ways work; the first lessens competition with other hungry creatures; the second opens up numerous possibilities, for if one kind of food fails, something else can be sought for.

The great French naturalist, Buffon, who died in 1788 (the year before the French Revolution), was greatly interested in the Tree-Sloths. But

Photo: F. W. Bond.

THREE-TOED TREE-SLOTH (*Bradypus tridactylus*).

This frequenter of South American forests is peculiarly well adapted for arboreal life. Thus the claws are long and curved, the limbs are also elongated. The shaggy hair is coloured greenish by an algoid growth. The food consists of leaves and the stomach has several chambers. The teeth are little pegs without enamel.

he quite misunderstood them, for he took them as examples of Nature making a mistake. " One more defect," he said, " and they could not have existed." Slow, quaint, queer, awkward, they may be, but they are extraordinarily well-fitted to live among the branches. There is, for instance, a touch of perfection in the peg and socket ankle-joint, so well suited for turning and twisting about. Then there is the way in which the mother, moving as usual back downwards along the underside of the branch, carries her single baby on her lap, as safe as safe can be.

Let us take a picture from " The Naturalist of the Amazons " (1864), by Mr. H. W. Bates, one of the great naturalist travellers. Speaking of the Three-Toed Sloth, he says : " It is a strange sight to watch the uncouth creature, fit production of these silent shades, lazily moving from branch to branch. Every movement betrays, not indolence exactly, but extreme caution. He never loosens his hold from one branch without first securing himself to the next, and when he does not immediately find a bough to grasp with the rigid hooks into which his paws are so curiously transformed, he raises his body, supported on his hind legs, and claws around in search of a fresh foothold."

We have selected two leaf-eaters—the giraffe and the tree-sloth—but we might have selected twenty without coming near an end of the variety. There are leaf-cutting ants (see the chapter on Storing), leaf-eating snails (see the chapter on Plants on the Defensive), leaf-eating caterpillars, like those of the terrible nun-moth, which leave a whole forest of fir trees stripped and naked. There are locusts that find a country a garden and leave it a desert, and the Colorado Beetles that do so much harm to the potato-fields in America (see the chapter on The Balance of Nature). On many a leaf in summer we see the strange twisting lines made by the minute grubs called leaf-miners, and there are scores of different kinds of these that levy heavy toll on leaves. Then there are the big grazing animals, like cattle, sheep, and deer. Hundreds of different kinds of animals feed on leaves.

§ 3

The great majority of woodpeckers are insect-eaters, and the holes they make on tree stems by hammering hard with their bill are made in search of boring grubs. They are well suited for their particular mode of life, for the bill is strong, the toes grip the bark (two forward and two backward), the tail-feathers are usually short and stiff, forming a prop when the bird has paused on the stem to extricate a grub, and the tongue is in most cases long, spiny and sticky at the end, very quickly shot out and drawn in. But there are a few sap-sucking woodpeckers, which feed on the sugary juice that oozes from the holes they make, and it is interesting to find that they have comparatively short tongues with numerous hair-like processes instead of spines, and thus well suited for supping up the sap. The tongue seems to be what one might call a changeable organ, and it often comes to be well fitted for the particular kind of food. The Yellow-Bellied Sap-Sucker is a very characteristic American woodpecker which does considerable damage to trees, making hole after hole with great rapidity till the stem looks " as if it had suffered from smallpox." This woodpecker has a short tongue with a somewhat brush-like appearance, and it cannot be protruded far—suited therefore for sap-sucking. Yet when it is feeding its nestling, it has to go back to the true woodpecker diet of insects. During that period of the year it catches flies on the wing. There can be little doubt that tapping the trees for sap is an after-thought. A queer fact is that certain woodpeckers occasionally take too much strong sap, like that of the maple, from which maple-sugar is made, and become for a time quite stupid.

Sap-Suckers.

In the early months of summer nothing is commoner on grasses and wayside plants than the frothy foam called cuckoo-spit. Many people who do not know about it regard it with repulsion, but it is quite clean and it has an exceedingly interesting history. If you take a piece of grass with the foam or froth on it and push aside the bubbles you will find in the interior a young insect—one of the frog-hoppers—sometimes green, sometimes yellow, sometimes pink. One of the commonest is called *Aphrophora spumaria*, belonging to the order of plant-bugs. Like all its relatives, it has a piercing and sucking proboscis, which it presses into the stem of the plant. It gets such a rich supply of sugary sap that it overflows with sweetness. Along the under side

The Story of Cuckoo-Spit.

THE SECRET OF THE CUCKOO-SPIT

The Cuckoo-Spit is not, as often believed, a repulsive substance, but is the evidence of a remarkably interesting nature story. This foamy secretion is made by the larvæ of the frog-hopper (*Philænus spumaria*), and is the surplus of the sweet juice sucked by the insect from the young, juicy stems of plants. By working its body up and down, the frog-hopper converts this overflow into a soapy mass. This serves to keep the insect moist, and helps to protect it from its natural enemies.

Photo: John J. Ward, F.E.S.

The adult winged insect, a member of the order of bugs Rhynchota. It is about a quarter of an inch long, of a variable colour.

Photo: John J. Ward, F.E.S.

Two frog-hopper larvæ. The upper one on right is about to produce frothy covering, the lower one has already begun.

Photo: John J. Ward, F.E.S.

Twenty-four hours later. The lower one has remained still, while the upper one has changed its feeding-ground. The froth consists of sap, a little ferment, and waxy secretion, beaten up with air.

Photo: John J. Ward, F.E.S.

The winged insect just emerging from its "cuckoo-spit." Its pupa covering is left behind in the frothy mass. There is less and less cuckoo-spit as the summer advances.

of its body there is a runnel in which air can be held, and the frog-hopper works its body up and down, until the captured air gets thoroughly mixed up with the surplus sweet fluid, which passes out of the food-canal. Just as the cook makes "whipped egg" by beating air with a spoon into the "white of egg," so this insect makes whipped sap. As it does so there is added a little wax from glands on the skin and a little ferment from the food-canal; and there is a beating up of the four things together—sugary sap, air, wax, and ferment—and the result is what may be called a soap—the cuckoo-spit. If it consisted only of bubbles it would soon disappear in the heat of the day, but, being something like a soap, *it lasts*; and this keeps the young insect moist. Moreover, very few enemies will touch the frothy mass, except an occasional wasp, which is not daunted by anything. So here is an insect that saves its life by blowing soap-bubbles! As the summer months pass we see less and less cuckoo-spit, for the frog-hoppers have taken to themselves wings and flown away.

Honey-dew.

The most dangerous of the many kinds of insects that infest plants are the Bugs (of the order Rhynchota), which suck the sap. If they got the upper hand the whole world of life would probably come to an end in a few years. Among these plant-suckers there is the family of "green-flies," "plant-lice," or Aphides, a description of which has been given in the chapter on Linked Lives, which do a great deal of damage. One sees them covering the stems and leaves of rose-bushes and pear-trees, beans and hops—a crowd of wingless insects which in the summer months are all females and multiply very quickly by virgin birth.

There are many interesting facts about honey-dew, but we are most concerned just now with the loss it means to the plants and the gain to the insects. In the mouth of the Aphis there is a proboscis, and inside this there are four piercing needles. This instrument is thrust into the stem or leaf, and it sometimes goes far in, reaching the tissues containing sugar and other reserves. In some cases a fluid is exuded from the salivary glands of the Aphis, and this hardens round the proboscis, forming an extra canal, within which the piercing and sucking instrument can work with great facility. How well fed the insects are may be gathered from the rate at which they multiply, for one cannot forget Huxley's calculation that if the progeny of one mother Aphis all survived and multiplied there would be at the end of summer a mass of green-flies big enough to weigh down the population of China. This does not happen, for the multiplication is checked by the limited supply, and also by the bad weather, and also by the appetite of the little beetles called Lady-Birds, the beautiful Lace-Wing Flies, and such birds as Titmice, which are all very fond of green-flies. In another chapter we have referred to the partnership that some kinds of ants have established with Aphides, which they utilise as their "cows." There is no doubt that they milk and tend the Aphides, that they carry the winter-eggs into shelter and look after them, and that they take the young ones in early summer to their leafy pastures.

Photo: F. W. Bond.

FRUIT-EATING BAT.

The larger bats, extending from Madagascar to Queensland, are all frugivorous. In the genus Pteropus, often called flying foxes, an expanse of five feet from tip to tip of the wing has been recorded. The fruit-eating bat is distinguished from the insectivorous forms by the great length of the prehensile tongue, employed for licking out the soft contents of tropical fruits.

§ 4

Other Vegetarians.

It is interesting to watch a cow grazing, to see how she uses her tongue to help her lips to gather a bunch of grass, which is then pressed by the lower front teeth (incisors) against the

Photo: W. S. Berridge, F.Z.S.

MALAY SQUIRREL.

The Malay, or Prevost's Squirrel, *Sciurus prevosti*, has a very wide range, but is principally to be found in the country from which it takes its name. It is one of the True Squirrels, and is distinguished by the red hue of back and tail, white breast, and grey cheeks.

toothless pad on the front of the upper jaw, and then bitten off. She fills her paunch full of the hastily swallowed grass, and then lying down she chews the cud. The grass comes up again, is well chewed, and then passes to the true digestive stomach. How different is this grazing of cattle, sheep, and deer, all of them cud-chewers, from the close cropping seen in the horse, where the lower front teeth meet sharply against the upper ones. And no odd-toed hoofed mammal is a cud-chewer.

Also vegetarian—though they seem worlds away—are the bees and other honey-collecting and pollen-collecting insects. Then there is the long list of fruit-eating animals, from the predominantly carnivorous wasps, which have a very sweet tooth and cannot keep away from the cherries, to the big bats that suck the juices of succulent fruits in the Far East. There is great variety in the way parrots feed, but many of them use their powerful bills to open up a fruit and their knobbed tongue to spoon up the contents. How quaint is the behaviour of a little Malayan Squirrel, which has learned to deal with the Coco-nut, not really a native of these regions. It tears off part of the firm outer husk; it pulls away the fibres and utilises them in nest-making; it gnaws a hole the size of a crown in the hard inner shell and goes in itself! It eats the nut, which is the seed, from the inside. There are many tiny grubs and the like that get into the inside of seeds, and devour them, but it is rather an achievement for a mammal.

We must not forget the leaf-cutting ants that grow a mould on the green paste which they make out of the chewed leaves, or the ambrosia

beetles that grow another fungus on the walls of the tunnels which they bore in the tree stem, or the baker-ants that chew the seeds of vetches into dough and make biscuits, which they dry in the sun. There is an astonishing list of queer vegetarians.

In recent years a new light has been shed on the diet of various insects that feed on hard wood. Thus the young stages of the Death-Watch feed on the old wood of the wainscot, and there are others that devour hard furniture. It seems an almost impossible food—very hard and very difficult to digest. But it has been shown that the food-canal of the Death-Watch has two little reservoirs containing yeast-plants, which bring about the fermentation of the wood. Every Death-Watch its own brewery! When the mother insect lays her eggs, some of her yeast-cells are entangled on the egg-shells. When the grub is ready to be hatched it bites its way through the hard shell, and thus gets infected with yeast-plants. A little leaven goes a long way with the Death-Watch. There are numerous similar cases. One, that of the termites and their partner Infusorians, has already been described.

XXIV
CARNIVOROUS ANIMALS

§ 1

FROM the simplest animals upwards to man, in class after class, there are carnivores, eating raw flesh. Even the most civilised men hold to the habit of their prehistoric ancestors of eating oysters alive. What a long series there is—the Night-Light Infusorian (Noctiluca), that makes the seas "phosphorescent," is big enough to capture worm-larvæ and minute Crustaceans; the beautiful sea-gooseberries or Ctenophores grapple newly hatched fishes; the sea-anemones in the rock pools often capture sea-worms; the starfish protrudes its stomach on young oysters, and the sea-urchin sometimes eats rock-barnacles; the ribbon-worms or Nemerteans are mostly carnivorous, and so are many of the ringed sea-worms like Nereis; crabs sometimes catch fishes, and centipedes prey upon earthworms; many of the sea-snails bore through the shells of bivalves; cuttle-fishes are very fond of crabs; sharks are good representatives of the predatory carnivorous fishes; toads often catch slugs; crocodiles lie in wait for young antelopes that come to drink at the edge of the river; the rattlesnake kills the rat; the Golden Eagle catches the grouse in its talons without stopping in its headlong flight; and so we reach the level of the tiger.

The True Carnivores.

As an example of a thoroughgoing carnivore we take the weasel, and there could be no better, for Britain at least, unless it be the stoat. The weasel and the stoat are near relatives and kindred spirits, but there is no reason to confuse them, as people often do. For the weasel's body is only about eight inches in length, whereas the body of a full-grown male stoat is often more than twice as much. The weasel's tail is a little over two inches long, whereas the stoat's is five or six, and ends in a black tip. Moreover, as everyone knows, the nut-brown stoat of summer usually changes into the ermine of winter, snow-white, except the black end of the tail, whereas the British weasel remains brownish above. At the same time it is quite correct to say that the weasel is a small edition of the stoat, and it is generally agreed that they are two species of one genus; in other words, first cousins. Practically, however, it is important to distinguish them, for even from the gamekeeper's point of view the reasons, such as they are, for killing stoats do not apply to weasels. For the evidence is clear that weasels feed mainly on small rodents, like field-voles and wood-mice, which are always apt to become dangerously abundant. No doubt weasels may levy toll on young pheasants, partridges, and

The Weasel.

other birds, and may in some cases make a habit of it, but their hunting is in the main beneficial, especially when the interests of farmers are regarded as more important than those of the game preserver. Weasels break the skulls of mice and voles; they bite larger creatures in the neck, and sometimes hang on grimly till the victim ceases to struggle.

What impresses one first about the carnivores of the weasel-stoat-polecat-marten tribe is their consummate fitness. The weasel's body is spare and lithe, perfectly adapted for exploring a burrow or for disappearing among the stones of a dry dyke. There is a suggestion of the snake in its sinuousness. The creature swims and climbs as effectively as it runs and leaps. For one must distinguish a rapid progression, with the body low and straight, from an even quicker succession of leaps and bounds. There is no flabbiness in the weasel and hardly any fat in its body. The colour of the upper fur harmonises with the soil and the withered herbage. The teeth are small but extremely sharp, and, for an eight-inch animal, the weasel can give a very shrewd bite. The senses of sight, hearing, smell, and touch are unsurpassed, and we suppose it is almost impossible to catch a weasel napping. They seem to be always on the *qui vive*, but this is not inconsistent with a considerable degree of preoccupation when they are playing or in hard pursuit of their prey. Intent is a word that describes them. It must be remembered that a good deal of their hunting is done at night, and Millais refers to the belief in certain parts of the country that hares are sometimes pursued in the darkness by packs of fairy hounds, the "Dandy Dogs." These are doubtless weasels, which often hunt in small companies—perhaps family parties. As in related animals, there is an education of the young ones by the parents or by the mother alone, and this may be the true interpretation of the hunting in small packs. At heart the weasel is an individualist, that is to say, he prefers to be "on his own."

Photo: C. Reid. *Wishaw, N.B.*

THE WEASEL.

This common carnivore, technically known as *Mustela nivalis* or *Putorius vulgaris*, is widespread in England, Wales, and Scotland, but absent from Ireland. It feeds chiefly on mice and rats, voles and moles, and should not be killed. It climbs and swims well. From a stoat it can be distinguished at once by its smaller size and short tail. Only rarely is the fur white in winter, though it is usually paler than in summer. The female is distinctly smaller than the male.

An impressive quality is the weasel's fearlessness. It is not the fearlessness of a penguin or a sea-cow, which is rather stupid and ignorant, but the fearlessness of wide-awake defiance. A weasel will tackle an animal many times its own size—a rabbit, for instance; it will face up to a dog; small packs have been known to attack man. This courage is, of course, most marked in a mother leading her family, but it is a quality of all weasels. It grades into an extraordinary pertinacity, an indomitable resourcefulness, of which there are many well-authenticated instances. Thus it is certain that when a starving bird of prey has gripped a weasel in its talons and flown away with it, the victory may be in the long run with the captive, who manages to give a fatal bite in mid-air. There is a wonderful doggedness about a weasel, but it is associated with presence of mind and courageous cleverness. "Never say die" is its motto, and the reward of the ages has been that the weasel has very few natural enemies. We are often impressed with the rewards that come to those creatures that practice self-subordination and mutual aid, but there is success also along the other evolutionary tack of self-assertive audacity. The weasel is "a braw fighter"—a gentleman unafraid.

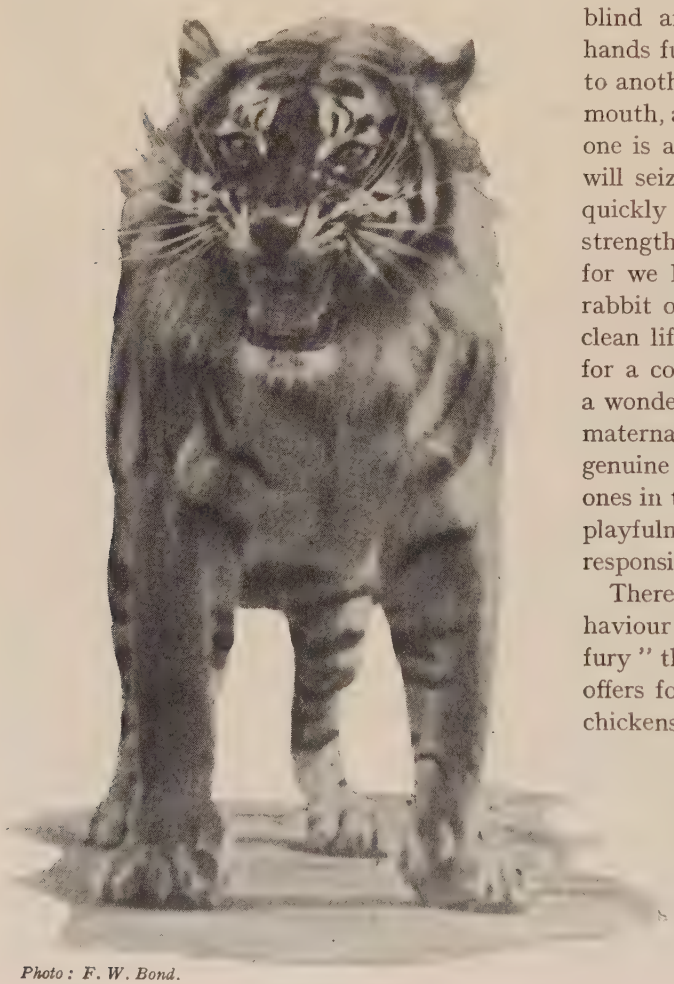


Photo: F. W. Bond.

THE TIGER (*Felis tigris*)

is about the same size as a lion, but distinguished, of course, by its stripes. These suit the shadowy jungle. It is an Asiatic carnivore, ranging from India to Siberia. A not uncommon size is nine feet six inches. The strength, often exaggerated, is certainly enormous.

The other aspect is well seen in the weasel's maternal care, for there is long nurture and careful education. In May or June the four to six young ones are born in a cradle among stones or in a tree-stump. They are for a long time blind and helpless, and the mother has her hands full. If danger threatens she shifts them to another shelter, carrying one at a time in her mouth, as a cat her kitten. Even when the young one is able to move about a little, the mother will seize it at a critical moment and carry it quickly into safety. There must be prodigious strength in the muscles of the jaws and neck, for we have seen a weasel dragging a biggish rabbit off the roadside into a thicket, and the clean lifting of the young one, and carrying it for a considerable distance at a smart pace, is a wonderful gymnastic feat. In addition to the maternal nurture and carefulness there is a genuine education. The mother trains her young ones in the ways of the wild, and in a delightful playfulness they serve an apprenticeship to the responsible business of their life.

There are some striking features in the behaviour of weasels. One of these is the "blood fury" they sometimes exhibit when opportunity offers for destruction on a large scale. Among chickens, for instance, they will kill right and left, victim after victim, far beyond all possibilities of immediate need. It is true that weasels sometimes bury their "kill," showing the first hints of a storing habit; but the meaning of the "blood-fury" is probably that an uncontrollable killing instinct is aroused, and kept aroused, by the sight of an unusual and sometimes unnatural abundance of booty. We have already spoken of the occasional intensity

Photo : Major H. Radclyff Dugmore.

LIONESS COMING AT NIGHT TO FEED ON THE REMAINS OF A HARTEBEEST, PROBABLY HER OWN KILL.

The lion (*Felis leo*) used to range into Europe, but is now confined to Asia and Africa. Its sandy colour resembles desert soil, but the lion needs no concealment. Even in hunting, it is chiefly nocturnal. It roars *after* it has secured its meal. The male is unique among cats in having a mane. There is a slight claw at the tip of the tail. Unlike the tiger, the lion does not climb trees. This remarkable flashlight photograph was taken, at a range of only ten yards, by Major Dugmore on one of his expeditions in the Tana River country.

of preoccupation. When two weasels are having a thoroughgoing quarrel they sometimes seem careless of interference. The same is true though the limit is more quickly reached, when the preoccupation is with a game or with display before birds. Perhaps the apparent recklessness points to a relatively limited intelligence of the "one-thing-at-a-time" order; but perhaps the explanation is to be found in the safety which the weasel has won for itself in the competitive struggle for existence. Another peculiarity, also well marked in stoats, is the occasional trekking or raiding in companies. Sometimes it is a family journey in which the mother leads her four or five kittens; sometimes there is a troop of twenty or more on the march in search of a new country. On such occasions it is profitable for both man and dog to exhibit discretion rather than valour. When a hard winter sets in and the ground is white the weasel makes tunnels beneath the snow, and its keen sense of smell often leads it to the hiding-places of mice and voles. In North Europe, though not in Britain, the weasel often changes into a white dress in winter. The so-called "white weasels" of Britain are very pale colour varieties or true albinos, not illustrations of seasonal change.

Photo: John J. Ward, F.E.S.

PARASITE OF THE PIG. Magnified twenty diameters.

This is one of the degenerate wingless insects in the order of lice, of which there are very numerous species. Many of them are restricted to particular hosts. They are, of course, blood-suckers.

As a special group of carnivores may be ranked those animals that depend mainly or wholly on insects, which seem to be exceedingly nutritious. The small bats hawk insects in mid-air and vie with the swifts and swallows among birds; the chamæleon is a good instance of an insectivorous reptile, focussing first one eye and then the other on its booty and then projecting its long glutinous tongue with deadly aim. The common toad is also an adept in shooting out the tongue on a fly, and the trout, which have thinned the ranks of the larval mayflies on the floor of the stream, may be seen "rising" to capture the winged adults. Between half-past four in the afternoon, when the mayflies began to dance over the water, to half-past eight in the evening, when the story came to an end, a trout of 2½ lbs. had caught 960 mayflies, with remains in the stomach weighing 2½ ounces; and there may have been some that were quite digested. Another trout, which we should call a true carnivore, had remains of 79 minnows in its food-canal. The insect-eating habit is very common among insects, and, again, there is astounding variety in the mode of capture: the dragonfly captures living insects on the wing, the larval tiger-beetle makes a burrow and uses its head as a treacherous trap-door.

Insectivores.

Most animals require solid food, and perhaps we should not regard blood-suckers as an exception. For blood is more than a fluid; it contains a multitude of blood corpuscles. Thus a flea is eating solid food much diluted, and is on a different platform from a tapeworm, which lives in the food-canal of its host and depends on the digested food that passes in a thoroughly fluid form through its skin.

Blood-Suckers.

Many insects besides the flea are notorious blood-suckers—the stable-flies, the mosquitos or

Photo: John J. Ward, F.E.S.

BED-BUG (*Cimex lectularius*). Magnified sixteen diameters.

This malodorous insect is one of the Rhynchota or Hemiptera. It hides in cracks and crevices, and hunts at night. Inside the beak or proboscis are four sharp needles, and the blood of the victim is sucked up after the puncture. The colour is rusty red. The fore-wings are very rudimentary and useless for flight. There are no hind-wings.

gnats (some of which spread malaria), the Tse-tse flies (some of which spread Sleeping Sickness), the lice (some of which spread typhus fever). The bed-bug, which seeks out its victims by night, is disagreeable enough, but it is not so injurious as its Indian relative, which is the carrier of a microscopic animal almost as serious in provoking disease as the malaria animal (Plasmodium), and the sleeping sickness animal (Trypanosoma). Very important also are some of the ticks which climb on to animals from the ground or from off plants, attach themselves firmly to the skin by means of a barbed proboscis, and proceed to suck blood. As in many other cases, it is often not the loss of blood that is serious, but the introduction of some microscopic organism that causes disease, such as relapsing fever in man, and Texas fever in cattle.

Many of the leeches are carnivorous, devouring small water-animals, but others are true blood-suckers. The medicinal leech, which used to be the doctor's pocket companion and panacea for the ills that human flesh is heir to, is in many ways admirably suited for making its livelihood by blood-sucking. It can move quickly and fasten firmly on fish or frog; in its mouth there are three semi-circular saws, each with about ninety microscopic teeth, giving a bite that lets the blood flow freely; it has a muscular pharynx that sucks the blood in; it has eleven pairs of capacious pockets so that it can store blood for hard times; it has a juice in its pharynx which prevents the blood clotting; and it needs so little food that a big meal may serve for half a year!

The blood-suckers of highest degree are the "Vampyres" of South America, near relatives of the big fruit-eating bats. The bat usually called the Vampyre is not a blood-sucker, but there are plenty without it. They fasten at night on cattle and other hoofed animals, and even on man; bite off a piece of skin the size of a split pea, and suck the flowing blood. They take as much as they can get, and their stomach, like that of some of the fruit-suckers, has a special storing reservoir. A good meal lasts them a long time, during which they lie dozing in their cave or hollow tree.

Devourers of the Dead.

Surprise is often expressed that one sees so few dead birds or mammals in the woods and meadows. Part of the solution is to be found in the fact that most animals die a violent death and there is nothing left to bury. The rest of the answer is to be found in the number of animals that devour dead bodies. Birds like vultures and marabout storks are great carrion-eaters, and the nakedness of their neck region has perhaps its advantage in keeping them from becoming too abominably filthy. But they are not pretty eaters. There is more restraint in the ways of the Butcher-birds or shrikes, which impale mice, shrews, lizards, and even large insects on the thorns of the hedge and dismember them at leisure, taking out the tit-bits.

Photo: John J. Ward, F.E.S.

PARASITE OF THE BEE. Magnified twenty diameters.

The Bee-louse, is a wingless insect which lives parasitically on the common humble bee. It is often found on the drones and queens but seldom on the workers.

THREE YOUNG KESTRELS, AWAITING THE RETURN OF THE MOTHER WITH FOOD.

The kestrel (*Tinnunculus tinnunculus*) is the commonest hawk in Britain. Its chestnut dress and its hovering are well known. It feeds chiefly on small mammals and insects, not very often on birds. The four or five ruddy eggs are laid, without a real nest, on a hollow ledge of rock or in an old tree. The young have at first a greyish down plumage.

Some animals stow away their booty, so that it becomes "high" and more readily eaten. This may be illustrated by the way in which a crocodile or an alligator buries the mammal that it has drowned by holding it under the water. In due time the dead body is disinterred and devoured. Many dead birds and mammals are very rapidly buried by the Sexton Beetles (e.g., Necrophorus), but in most cases this is to provide food for the grubs, which hatch out from the eggs that are laid in the body. In the same way the Blue Bottles and other flesh-flies are attracted by smell to the exposed flesh, and find in it a suitable place for the rapid deposition of their eggs. The flesh is then said to be "blown," and it seems that the salivary juice of the maggots, exuding from the mouth, begins to digest the food before it is eaten. It is

THE MOTHER KESTREL RETURNING WITH MOUSE.

The kestrel is a partial migrant in some parts of Britain, a resident in others. As its name, "wind-hover," suggests, it is an adept in poising above a possible victim, with the wings moving up and down with great rapidity. It can dive and seize the mouse and re-ascend without stopping. Its vision is remarkably acute, even among hawks. Other birds often mob it. The male bird usually takes some share in brooding.

a terrible thing sometimes when a flesh-fly lays its eggs in the rubbed skin of a sheep, for the hatched maggots will begin to devour the living animal if the shepherd is not watchful. The same may happen with deer and other animals.

If we may say so, Nature is all for cleanliness. What has passed out of the circle of life is soon removed, being in part incorporated in changed guise in another creature, or in part reduced to water, salts, and gases which plants may re-capture. It is interesting, though perhaps not very attractive, to study the succession of insects and other living creatures which may be found working at the dead body of a sparrow or a mouse, for there is usually a somewhat regular chain of creatures which are able to use the decomposing remains at different stages. From the beginning to the end there are, of

Photo: John J. Ward, F.E.S.

FEMALE MALARIA MOSQUITO.

The mosquito, which is a kind of gnat, is not uncommon in Britain, but it does not carry the malaria organism, as in warmer countries. Besides the chief carrier, there is the dapple-winged *Anopheles maculipennis*, marked by four dark spots on each wing.

course, Bacteria, for without them there is no true rotting. At the end there is left of the dead rabbit on the links just a few bones and a patch or two of fur that has not blown away, and if these are carefully examined there will often be found a tiny roundish beetle (e.g., Ptinus), which seems determined that nothing shall be wasted. In the same way in a shore-pool we may watch small sand-hopper-like creatures (Gammarids) nibbling away at the remains of dead animals till nothing is left.

Sacred in the eyes of the Egyptians were the dung-beetles called Scarabees, whose image was often used as a symbol. There are various kinds, like the Mediterranean Ateuchus and the North European Sisyphus, which is named after the mythical personage who was condemned to push a stone uphill only to have it roll down again when he got near the top. That is the sort of thing the scarabees do with balls of dung (e.g., of horse and sheep), which they push before them, up hill and down dale, often for a long distance. A dung-ball is often the size of a marble, and the male and female beetles unite in rolling it to the underground nest which they have excavated. There they eat it at their leisure. They make another kind of ball, which they also trundle along and hide underground, but it is for their offspring, not for themselves. Fabre has given a fine description of one kind where the ball made for the egg is shaped like a pear. At the narrow end there is a little cavity for the egg, and the dung round about is specially prepared by the mother-beetle. The outer layers of the pear are specially hard and firm, so that the interior remains soft and moist even in dry weather, and is well suited for the grub when it hatches from the egg.

Dung-eaters

On the patches of cow-dung in the meadow we often see a crowd of bright yellow flies, sometimes so much engrossed that they do not rise at our approach. They are laying eggs in the dung, for they themselves feed more daintily on plants and sometimes on other insects. But there are other flies which are themselves dung-eaters, and so it is with animals of lower degree, such as many of the threadworms. It will be evident that some of the dung-eaters, such as scarabees, might be ranked along with vegetarian animals, for the horse's dung consists of undigested fragments of hay and the like. But we cannot classify diets in a very hard and fast way. The general term " saprophytic " is used for all creatures, whether animals or plants, that

Photo: Jaques Boyer.

HEAD OF FEMALE MALARIA MOSQUITO (*Anopheles maculipennis*), showing proboscis and thread-like lancets—highly magnified.

The mouth parts of this insect are very complicated, containing, as they do, several sharp needles in sheaths.

Specially drawn for this work by Roland Green, F.Z.S.

THE SACRED BEETLE (*Scarabæus sacer*)

occurs in the south of Europe, in Egypt, and other countries. A ball of cow's dung or the like, sometimes bigger than a golf ball, is fashioned by the female and rolled along the ground to the underground retreat. It may be kicked by the hind-legs or pulled by the fore-legs. Another beetle, usually another female, may help. The ball of dung is eaten. A special ball is used as a cradle for the eggs.

Photo: Neville Kingston.

THE CROCODILE.

The fine photograph of this huge reptile's head shows the numerous sharply conical teeth, which are fixed in sockets—the only instance of this outside of mammals. Behind the eye is the ear-opening, which can be tightly closed by a well-fitting lid, keeping the water out. On the top of the snout is the valved nostril and the crocodile is thus able to hold animals under water in its jaws until they drown, keeping the tip of its snout above the surface.

live on decomposing materials, but it is more interesting from the Natural History point of view to distinguish carrion-eaters, dung-eaters, and so on.

Eaters of Hair and Horn.

There is a special reason for taking notice of creatures like clothes moths, whose minute caterpillars live on woollen materials, or on the hairs of furs, or on the skins of museum specimens. There are also some insect larvæ that breed on the sheath that has come off the horn of a dead ox, or on the hoofs of a dead horse. What is it that they are eating? Whether it be hair or "horn" or hoof, it is the material called keratin or horn, which we have, for instance, in our finger nails; and the point is that one cannot think of a more unpromising kind of food. The idea of lunching on a clothes brush! The solution seems to be the same as in the case of the death-watch. Some at least of the insects that live on very unpromising materials like horn have partner-yeasts in their food-canal, and these are able to bring about the fermentation of what would otherwise be very unprofitable. The larval clothes moths must thrive, for everyone has probably seen them fly away. But let us turn from these dark affairs and consider the plankton-eaters of the Open Sea.

§ 7

The Plankton-Eaters of the Open Sea.

The peculiarity of the harvest of the sea is that man is ever gathering it in, and yet giving almost nothing back. If he did this on land there would soon come about an exhaustion of the soil; hence the use of fertilisers. But in the sea the exhaustion is rarely more than temporary and local. It can be soon compensated for by giving the area a rest. How is it that man can take so much out of the sea and put almost nothing in? As is well known, the answer is to be found in the circulation of matter. Microscopic marine organisms possessed of chlorophyll utilise the energy of the sunlight to build up carbon compounds from carbon-dioxide and water; they form the floating sea-meadows on which

small animals depend, or they give rise to organic dust, which is borne outwards and downwards on the sloping floor of the sea. From one incarnation to another the nutritive material is raised, and the fishes are fed. This is the fundamental fact regarding the harvest of the sea: fishes are merely links in an endless nutritive chain. "What have I to do with barnacles?" the skipper may say; but the minute roving larva of the shore-barnacle is an important item in the dietary of young turbot when about one-tenth of an inch long. We cannot say that the welter of water-fleas and other small fry is there in the sea *in order that* there may be fishes; but it is a fact that the broad foundation of prolific minutiæ makes the great superstructure of fishes and fisheries possible.

The patient investigations of workers like Dr. Marie Lebour on the contents of the food-canal of larval fishes, often no longer than a four-lettered word of this type, have shown the fundamental importance of the minute animals of the sea. The very young stages of plaice and herring and some other fishes eat diatoms and other unicellular organisms, but these are of much more moment indirectly, inasmuch as they afford sustenance to the small animals on which young fishes mainly depend. By far the greater part of the food of very young fish consists of larval Copepods—minute Crustaceans which swarm in incredible numbers in the open sea. They feed on diatoms and the like, eating almost one-tenth of their own weight in a day, and fishes feed on them. The food-canal of a single herring may be crammed with a compact pink bolus of 60,000 specimens of one species of Copepod! Next in importance are the bivalved Cladocera, belonging to another order of minute Crustaceans popularly called water-fleas. Then there are the free-swimming larvæ of rock-barnacles, which are widespread in open waters and are devoured in prodigious numbers; and along with them we may notice the larvæ of other marine animals, such as Gasteropods and Bivalves. Miss Lebour has proved up to the hilt the cumulative importance of microscopic living creatures in the sustenance of one of the greatest of human industries. She has shown that young fishes, like herring and brill, begin to eat very early, while their yolk-sac is still unexhausted; that they feed very specifically or daintily, preferring one particular kind of Crustacean and sticking to it, thus affecting their struggle for existence, and that the presence or absence of the right kind of food at the right time means life or death to the fishes. It is obvious that the distribution of food-fishes, a matter of great practical importance to man, must be bound up with the distribution of the "small game of the sea"; and it may be that a deleterious influence, such, perhaps, as oil on the waters, may operate disastrously, not directly on the fishes themselves, but on the delicate creatures on which they feed. This question requires further investigation.

§ 8

The Story of the Oyster-Catcher.

In illustration of the quest for food let us take the case of the Oyster-catcher, a common resident bird in Britain, with its counterpart in America. It is an attractive bird which everyone can recognise at a glance, for it has conspicuous black and white plumage (hence its name Sea-Pie), an orange-vermilion beak, and bright flesh-coloured legs. It flies at a breakneck speed, crying very loudly "quick, quick," or "huick, huick." It is a bird of the shore, but when spring comes many of them go up the northern rivers in a merry throng. They fly high and low, always as if they were in a great hurry, but they are simply playing themselves. As April passes the crowd splits up into pairs, though often you see them flying in threes—a female and two males. They are courting, and the female bird is long in making up her mind which of her suitors she likes best. The male runs along the sandy bank and pipes to her, getting a trill into his simple "song"—"kerree, kerree." He bows and sways from side to side, and his neighbour comes and does the same. The rivals frequently rush at one another. But all they say and do is often love's labour lost, for the female seems to get bored and walks away.

After a while, however, they pair, and make a very rough and ready nest—little more than a few pebbles and shells and pieces of drift. This apology for a nest is made in a sandy nook among the rocks on the seashore, or among the dunes, or on the shingle by the stream. A favourite place is on a little river-island.

Photo : T. M. Blackman.

OYSTER-CATCHER AND ITS EGGS.

One of the plover family (*Hæmatopus ostralegus*), with conspicuous black and white plumage, a long, stout, orange-coloured bill, and flesh-coloured legs. It is a sociable bird, often spending the winter on the estuary shore, and the summer by the gravelly banks far up the rivers. The nest is little more than a scrape in most cases. There are usually three yellowish, blotched eggs, far from conspicuous.

The eggs, usually three, are much less conspicuous than one would expect, for they have dark spots and blotches on a yellowish ground colour. Both parents share in the brooding, and the male often watches while his mate sits. If an intruder appears, the male sounds the danger-signal and the female slips quietly off the nest. She runs along the ground for some distance, and then the two of them take up a position from which they can see what happens. They are anything but timid birds, and will defy enemies much larger and stronger than themselves.

The nestlings are well hidden by their grey and black down, and they squat when they hear the parents' danger call. They would readily escape notice if they remained quiet, but they are not so patient as some other young birds, and they are apt to betray themselves by getting up and trying to run before the danger is past. They grow quickly, however, and are able to fend for themselves in about three weeks.

At the end of summer the oyster-catchers that have made many a river merry, rejoin their kindred who remained near the seashore. The river-birds feed mostly on small water animals, such as insect-larvæ and water-snails, which they find under stones and among water-weed; and they are often to be seen on the farmer's fields, probably on the search for earthworms. It may be mentioned that the turnstone, a sort of second cousin of the oyster-catcher, is in the habit of tipping over flat stones and bunches of seaweed for the sake of the sand-hoppers, worms, and other small fry which it finds underneath. One of the chief lessons to be learned from a study of the quest of food is that *in many cases* each kind of creature has its own ways. What are the oyster-catcher's ways?

Photo: G. C. S. Ingram.

TWO NEWLY-HATCHED OYSTER-CATCHER CHICKS AND AN UNHATCHED EGG.

The down of the newly-hatched oyster-catcher chick is light-grey with darker mottlings. This makes them very inconspicuous among the many-coloured stones on the shingle, whether it be on the seashore, or by the river-side and loch-side. When danger threatens, this protective resemblance may be very useful.

We wonder why the bird was called oyster-catcher, for has anyone ever seen it catch an oyster? It is a past-master, however, in dealing with mussels, which form a considerable part of its food in places where they are abundant. It has at least three ways of tackling mussels. First, it waits for the proper state of the tide, when the mussel beds are covered with shallow water suitable for wading in. For when water covers them the mussels allow the valves of the shell to gape; they are feeding on inswept microscopic organisms. The oyster-catcher, wading quietly, sees a gaping shell, and instantly its strong bill is in and the business is half over. It cuts at the muscles that keep the valves shut; the shell opens up; the palatable flesh is spooned out, and then the oyster-catcher uses its bill like a pair of scissors and shears off any pieces of muscle and skin that have been left adhering to the inside of the shell

valves. The bird works with great quickness, for if the tide is coming in, the water above the mussels will soon be too deep for even a long-legged water-wader, and if the tide is going out the mussels will soon be exposed to the air and will close their shells tightly.

But the oyster-catcher is by no means baffled by closed shells. It is able to give blows so shrewdly that it opens the shell, often with very little breakage. The most interesting point is that the oyster-catcher alters its mode of procedure according to the way in which the mussel is lying. For all mussels are not fixed to the rocks in precisely the same position. It is in these little adjustments that we get glimpses of controlling intelligence.

The third way of dealing with mussels is to swallow them outright, but this is possible only when they are comparatively small. This is the method that the oyster-catcher also uses in dealing with periwinkles—the poor man's oyster—with small crabs, with worms, and many other shore animals.

Photo: T. M. Blackman.

OYSTER-CATCHER ON ITS APOLOGY FOR A NEST.

When oyster-catchers are running about they are very conspicuous birds, and still more so when flying. They advertise themselves with their ringing cry, "*feet, feet.*" When nesting, in a normal environment, they are much less conspicuous; but an interesting feature is the new courage that the nesting bird shows in its aggressive resentment of intrusive enemies, including man.

Its way of treating limpets is peculiarly interesting. Everyone who has visited the seashore knows that these molluscs, with their conical shell and adhesive "foot," cannot be *forced* off the rock. If you try to do this, you are more likely to break the shell or your walking-stick. The only way is to take the limpet by surprise, and give a quick, firm knock, which sends the shell flying. Now the oyster-catcher does one of two things. It watches for a limpet on the prowl, for they make little journeys in search of seaweed, and when they are on the move the "foot" is gliding, and the margin of the shell is raised a little off the rock. That is the oyster-catcher's opportunity. In goes its bill and off comes the limpet. The bill is strong enough to be used as a lever.

The oyster-catcher's second method of dealing with limpets is less frequent, but it is not less effective. The bird, moving quietly, suddenly gives the limpet a sharp sideways stroke, delivered with great velocity, and just at the proper place. This dislodges the limpet, and the rest is easy. The oyster-catcher often carries its limpet to a particular spot and there scoops it out of the shell. Great numbers of empty limpet-shells are sometimes found lying together on the shore, and these testify to the oyster-catcher's hearty meals. They correspond to the "kitchen middens" of prehistoric man—great banks of shells, the tell-tale evidences of many a feast. But our point was simply to take a common bird—as the oyster-catcher is—and discuss its varied quest for food.

It is "a far cry" from the sea-shore oyster-

catcher to the Praying Mantis, but they agree in their thoroughgoing carnivorousness. Perhaps the mantises are the most whimsical of all insects. It is not merely their attitude of apparent devotion that is striking, but they are strange in their tendency to form leaf-like expansions on their sides and limbs, in the formidable toothed shears with which they seize their booty, in their stealthy movements, in their wasteful voracity, and in the confusion of the amiable and the edible in the female's mind. A fine description of them has been given by Fabre, but we must not repeat his gruesome tales; it is enough to say that there is cannibalism among the mantises, and the female of the well-known European species, *Mantis religiosa*, does not hesitate to devour her own mate.

The Story of the Praying Mantis.

Yet they look all innocence, standing so quietly in a half-upright position, with bowed heads and folded arms. It is the large size of these front legs that brings about the semi-erect pose and the unconsciously hypocritical supplicating. "Soothsayers" they are sometimes called, and there are pretty stories about their kindness in pointing out the way a wandered child should take! But all the time the mantis is after the main chance, and when it has focussed its insect-victim, the long limb sweeps out, and one toothed part shuts upon another toothed part. The contrivance reminds one a little of an instrument sometimes used in pruning the high branches of trees: a hinged, sharp blade at the end of a long pole is "pulled to" with a rope, and snaps the branch off. The mantis holds its toothed leg to its mouth, bites off a piece of the victim with its jaws or mandibles, then moves it away again, and looks at it before the next bite. The creature reminds one of a schoolboy eating an apple and between bites scrutinising its diminishing bulk.

But often the mantis throws away its booty half eaten, and catches another. Like carnivores of higher degree—stoats, for instance,—it is very wasteful, destroying more than it eats, and we suppose that the explanation is the same in both cases: the presence of a victim pulls the trigger of an irresistible killing instinct. Perhaps we should have said that mantises belong to the cockroach-cricket order of Orthoptera, and that they have specialised as carnivores. They are related to the leaf insects and walking-stick insects, which are strictly vegetarian.

Most mantises move slowly, and are unsuited for flight. Probably, therefore, it is of survival value to them that they should be like their surroundings, as is very strikingly seen in some of those that live habitually among leaves, or lichens, or even flowers. The cloak of invisibility is equally effective in those that frequent the brown desert. In the common praying mantis there are two varieties, green and brown, and the Italian naturalist, Cesnola, proved the protectiveness of the colouration by precise experiment. With silk thread he tethered twenty green mantises among green herbage and a similar number of brown ones among withered grass. After seventeen days his tethered prisoners were all alive and well, having escaped the notice of their enemies. Cesnola then tethered twenty-five of the green variety among brown herbage; all were dead after eleven days. In the converse experiment, of forty-five brown mantises exposed on green grass, only ten

Photo: F. W. Bond.

A MANTIS (*Empusa equina*) FROM SPAIN.

The mantises or praying insects form a large family in the locust-grasshopper order Orthoptera. There is a great elongation of the region that carries the first pair of legs—the prothorax—and these legs are specially suited for seizing and holding the prey, which consists of living insects. The mantises are very voracious.

survived at the end of seventeen days. Most of the mantises that perished were killed by birds ; a few of the green ones were eaten by ants. This experiment is very conclusive, and it is plain that in a parched land the brown variety would prevail, while amidst luxuriant verdure the advantage would be with those wearing the green.

The praying, or rather *preying*, mantis does not occur as a native insect in Britain, but it is easily kept alive in well-sunned surroundings. It is common in Europe as far north as Havre. It seems to be a Mediterranean species, of Tertiary origin, that has spread northwards, working its way up such valleys as the Rhône. It is well represented in the Valais, e.g., near Martigny, and in Provence. Its predilection is for dry atmosphere and abundant sunshine. It is a successful animal, occurring not only in France and Switzerland, but in Germany, Austria, Italy, Russia, North Africa, and as far east as China.

A large South American mantis has been known to secure a small bird. It was beginning to eat it when the observant entomologist intervened and secured both. The European mantis keeps to insects. When it is young it feeds on small creatures like green flies ; by and by it aims at larger booty, such as blue-bottles and butterflies. It is said to be consistent in refusing to have anything to do with caterpillars. Even from the first there is cannibalism.

Photo : F. W. Bond.

EGG CLUSTER OF PRAYING MANTIS.

The female insect fastens a foam-like secretion to twigs, and this hardens into a firm case, shown in the photograph. Inside there are numerous symmetrically arranged chambers, in which the slowly developing eggs are disposed.

The life-history of the praying mantis includes three chapters. First, there is the embryonic period inside the egg, hidden in the egg basket, which is fastened to a twig or a stone. In Switzerland, for instance, this chapter lasts from autumn (September to November) till May. If the egg basket is transferred to a warm room the hatching may take place as early as February. The second chapter is the larval period, which lasts from the hatching till August. The larvæ wriggle out from the compartments of the egg-basket by means of spines on the temporary sheath that covers their bodies. Let us think of a sack-race, with the sack over the head as well. They contract and lengthen ; they press against the framework of the egg-basket ; the

Photo : Hugh Main.

PRAYING MANTIS (*Mantis religiosa*).

This voracious insect is common in the South of France and in Italy. It holds itself in a semi-erect position, stretching out its formidable front legs. Its voracity is extreme, and it does not spare its own kind. In many cases it tears off a few pieces of the insect it has caught, and then proceeds to catch another.

spinosities all point backward ; they win their way through. In some tropical mantises the emergent larvæ hang themselves upside down in the air by means of two threads issuing from two minute appendages (cerci) at the posterior end of the body.

There they hang, for hours or days, till their first moult is accomplished. The third chapter is that of adult life, which lasts in the European " soothsayer " from the middle of August, the time of the final larval moult, to late autumn. The male mantis lives for a month, the female from three to four months.

The egg-basket (or ootheca) is a remarkable structure, well suited for the protection of the eggs and embryos throughout the winter. The specimen we have in our museum is about an inch and a half long, greyish-yellow in colour, convex on its free surface, with a groove on the other for attachment to the twig. The female insects form this as a foam-like secretion, consisting of a substance allied to silk, which dries into a firm resistant fabric. Fabre describes the complicated fashioning of the egg-basket by the mother-insect, and Bugnion has recently added some finishing touches to the story. The important facts are the formation of internal compartments, one for each egg, and the enclosure of these in a thick zone like consolidated whipped egg.

Professor Bugnion found that it took a mantis larva that had become restless about twenty minutes to make its way out of its cradle. It was still wrapped up in a sheath, with backward pointing roughnesses useful in the wriggling, but this ruptured in the twinkling of an eye when the little creature got its head out and its body half free on the surface of the egg-basket. At the head end of this envelope or sheath there is a yellowish and resistant conical cap, which is very useful in resisting friction on the way out. Two threads that come from the posterior end of the body bind the sheath to the wall of the original compartment, and may be nearly half an inch long. When the surface is reached the threads assist in the liberation of the newly born larva from its sheath. In *Mantis religiosa* there does not seem to be any suspension in the air, as in some other mantises, for the young " soothsayers " proceed at once to creep about on the surface of the egg-basket. But there is a sufficient abundance of fitnesses without the spider-like rope trick. What an imagination Nature has !

XXV

STRANGE WAYS OF FEEDING AMONG PLANTS

THE most important process in the whole world is what goes on in every green plant in the sunshine—the process of building up sugar and more complex carbon-compounds out of the carbonic acid of the air and the salt-laden water from the soil. In so doing the living matter of the green cells, usually in leaves, is aided by the energy of the sunlight, and this requires to enter through a screen of the green pigment called chlorophyll. This process is called *photosynthesis* —building up with the help of light. Green plants are traps to catch sunbeams. Now this is the ordinary way in which plants feed, but we wish to consider some *strange* ways of feeding.

Thievish Plants.

Since green plants can use the inexhaustible energy of the sunlight and the inexhaustible food-supplies of the atmosphere and the soil-water, it seems strange that any of them should become thieves or parasites. The answer is that some plants are rooted in soils where the most important salts, such as nitrates like saltpetre, are scarce; that others live in boggy places where water is abundant, yet not available except for plants with special fitnesses for the situation; that others are terribly overcrowded, as in the meadow, and can survive only by filching; and that others live in places where they are so overshadowed, as in the tropical forest, that they can continue to exist only by tapping their lofty neighbours. Sometimes the thieving comes about very readily because birds plant the seeds on the branches of a tree.

The Story of the Mistletoe.

The missel thrush is fond of the jelly of the white berry of the mistletoe, but as it does not like the seed it cleans it off its bill on to a branch, perhaps of an apple tree. The seed is glued on and it sprouts. Tiny rootlets work their way into the branch and reach the growing layer or cambium. This is all that happens the first year. In the following year the rootlets enter the green wood of the branch and begin to absorb the ascending crude sap, which consists mainly of water and salts from the soil. The young mistletoe develops a green shoot and green leaves, and these can manufacture carbon-compounds in the usual way. All that the mistletoe requires from its host is soil-water, so it is only half a thief. It does very little harm. Its great beauty is surely to be thought of along with the fact that it has by no means lost all its independence.

Perched Plants.

One of the features of the Tropical Forest, as we shall afterwards see, is the abundance of "perched plants" or epiphytes, which live on the branches or stems of trees, quite independent of the earth. Some of them accumulate round their anchoring roots a little vegetable mould and *débris*, and this is occasionally added to by the earthen tunnels that white ants build up the stem and along the branches. Many of these perched plants are Orchids, and bear very gorgeous flowers.

The aerial roots are interesting in several ways. Thus they do not show the root's usual strong tendency to make for the centre of the earth, but spread round the supporting branch. They sometimes have a silvery and spongy rind, which helps them to absorb the water-vapour from the steamy air of the forest. It has been recently discovered that some of these Perched Plants have partner-Fungi living in intimate co-operation with them, and helping them to absorb moisture and the products of decay. This discovery is now being utilised in the cultivation of orchids. For whereas the old difficulty was that the seeds of the cultivated orchids would not sprout, it has been discovered that they require no coaxing at all if they are provided with a little of the appropriate partner-fungus. But why we wish to think of Perched Plants just now is because there is good reason for believing that some of them have led on to thievish or half thievish plants, like the mistletoe. Similarly, some of the Fungi which fed, to begin

with, on the products of decay, seem to have got into the habit of feeding on living tissues, becoming thoroughgoing parasites.

Partners and Parasites.

Every year adds to our knowledge of the remarkable partnerships that are established between plants of different kinds. Many a tree gets on well because it has a fungus feltwort (called mycorhiza) closely wrapped round its roots, sometimes keeping to the outside, sometimes getting inside as well. This partner-fungus helps the roots of the tree to absorb the soil-water. The heather succeeds on the very difficult moorland soil, where few plants can flourish, because it has a partner-fungus that grows through and through it, from root to shoot, from leaf to flower. We are accustomed to think of the heather as a very hardy plant, but its secret is that it has entered into partnership.

Plants of the Pea order (Leguminosæ), such as lupins and clovers, often get on well in very poor soil, and they are sometimes ploughed in to make bad soil better. They have little swellings or tubercles on their roots, and these are full of partner-Bacteria, which enable the roots, in some mysterious way, to capture and utilise nitrogen from the air mixed with the soil-water. There is a stuff called "nitragin," which is sold by seedsmen, and consists of millions of the nitrogen microbes. It is used to infect the seeds of clovers and the like with the friendly microbe. In most cases, however, there are plenty of the nitrogen-capturing microbes in ordinary soil.

Photo: John J. Ward, F.E.S.

ROOT TUBERCLES OF LABURNUM.

Inset: BACTERIA FROM THE NODULES, HIGHLY MAGNIFIED.

The roots of leguminous plants are invaded by a microbe (*Bacillus radicicola*), which sets up swellings. The invaded cells grow and multiply till a tubercle is formed. It is found that the nitrogenous substances in the plant increase, and experiments prove that the partner-microbe is able to fix the free nitrogen of the air.

There are many of these curious partnerships between plant and plant, and it is very likely that this is another way in which thieving might arise. A partner may easily sink down into a parasite. On the other hand, it is possible that a parasite may sometimes be converted into a useful partner, and this is believed to have been the case with a strange plant, the Bird's Nest (*Neottia nidus-avis*), found in dark woods.

Root Parasites.

When a number of trees of the same kind (e.g., Conifers) are growing close together, they sometimes unite by their roots, so that a sort of society is formed. If one of them is cut down its stump may go on increasing its girth for some years, although it has no leaves to feed it. How is this puzzle to be explained? The answer is partly that there are reserves stored up in the stump, but partly that contributions are coming to it from its neighbours through the fused roots. It is also said that if one of the company be killed by

Photos : T. Alexander Barns.

TREE FESTOONED WITH ORCHIDS.

Orchids that live as perched plants or Epiphytes, quite off the ground, are usually provided with a silvery tissue round their roots. This greedily absorbs rain and water-vapour, and passes it on to the interior. *Inset :* Flowers of the Gentilii, a wild variety of the Thomsonianus Rolfe species of orchids, found by Mr. T. Alexander Barns 5,000 feet above sea-level, in the Central Congo. The centre of the beautiful flowers is mauve, and the petals white, suffused with a delicate mauve tint

Photo: A. W. Dennis.

THE TOOTHWORT: A ROOT PARASITE.

The toothwort (*Lathræa squamaria*) infests the roots of the hazel, and is quite dependent on its host. It has no chlorophyll, and the leaves on the underground stem are curiously like teeth. A wan flower-stalk rises above ground. The plant belongs to the same order as eyebright and yellow rattle (Scrophulariaceæ).

lightning, the others may suffer. In any case it has been proved by experiment that there may be a useful union between the roots of different plants. These need not be of the same kind, for a successful union has been effected between the roots of a Passion Flower and a Spindle Tree. It is like root-grafting, and it is very interesting because it shows how readily root-parasitism might begin. In poor pasture the roots of the Yellow-Rattle, the Lousewort, and Bartsia may enter into close union with the roots of grasses and absorb nutritive materials from them. The grasses get on better than many other plants because their long strap-like leaves grow more or less vertically and do not get in one another's way. So other plants batten on the grass.

The Lousewort (Pedicularis) is a very common plant in poor soil that is also damp. It has rather pretty purplish flowers and deserves a pleasanter name. The reason for the name is to be found in the fact that sheep pastured in places where the lousewort is common are apt to become infected with lice. But this is not because of the lousewort, it is because the pasture is so poor that the sheep get out of condition, and then parasites are apt to increase.

The Story of the Toothwort.

One of the strangest plants in Britain is the Toothwort (*Lathræa squamaria*), so unlike anything else that we get a surprise if we discover it in its haunts. "Discover" is a suitable word, for it is often half-buried among withered leaves, snuggling in near the base of a hazel-bush in a dark wood. It is a wan ghost of a plant without any chlorophyll, with long flower-stalks rising from a prostrate stem, which is covered with white, fleshy, scale-like or tooth-like leaves, each enclosing a small cavity with water-secreting glands projecting inwards from its walls. The exudation of water from these glands keeps up the circulation of soil-water within the Toothwort. No plant is more dependent on its host than the Toothwort. It is a root-parasite, and obtains from its host not only the requisite water and salts, but worked up food material

as well. It can do nothing for itself, and there is probably no truth in the old idea that the hollow leaves absorb the products that result from the decay of small animals that find their way into the cavity and cannot get out again. But this question should be looked into once more. A very interesting point about the Toothwort is that its seeds will not sprout except in the vicinity of some suitable host-plant, such as hazel. This has been noticed in regard to some other thievish plants, and we should like to know more about it. Another of these root-parasites is the brown Orobanche, which is also without any green. In both cases the thieving habit is an indirect answer back to the difficulties of life in thick copses and similar places, where the upper growth is so luxuriant that it shuts out the light.

Photo: A. W. Dennis.

DODDER GROWING ON GORSE.

When the leafless dodder stem, reddish and thread-like, has coiled around its host, it sends out minute suckers, which penetrate the tissues. These absorb the requisite food, for the dodder, having no chlorophyll, cannot make any for itself, as ordinary green plants do. Thus the dodder must be called a total parasite. It has numerous pale-pink flowers in clusters.

The Story of the Dodder.

On a stem of wheat, or clover, or hops, or nettle, we sometimes find a remarkable climbing-plant, whitish in colour, with hardly a trace of leaf, and with small pinkish flowers. This is the dodder (Cuscuta), and it is more than half a thief. Out of the seed there comes an almost worm-like young plant, with the faintest trace of green. It can live for a few weeks half starving, but if it does not find a plant to climb on it dies. The young root is fixed in the ground; the growing shoot rises in the air and moves round and round, as if seeking for a support. Its loose, free movements seem to be mainly due to the influence of gravity on the growing shoot; they are like the movements of such twining stems as those of hops and scarlet runner. But the worm-like growing shoot is sensitive to contact, and if it touches the stem of a clover or some other suitable plant it begins another kind of movement, more horizontal and more tendril-like. The result of this is a tight coiling round the stem of its bearer, and from the surface of close contact there grow out minute suckers which tap the clover's supplies. Meanwhile the shoot has grown on and is describing more

Photo: E. J. Bedford.

LESSER DODDER.

The dodder (Cuscuta) is one of the convolvulus order that has become a leafless and rootless parasite. The seed does indeed germinate in the ground, but the root is only for temporary anchorage. The growing shoot describes small orbits, and it is clearly seen in the centre of the photograph, twining upwards and fastening on one of the leaves of its host. When it has found one, the root dies away.

circles, so that it soon fixes itself higher up. Then the connection with the soil is broken and the dodder becomes altogether a thief. Some of its suckers penetrate into the part of the clover stem where the soil-water ascends, and some of them absorb the manufactured material, for the dodder can do nothing for itself. Perhaps we should say "*will* do nothing," for experiments show that if the coiling and the sucking be prevented, the dodder can green a little and live independently for a short time. Some tropical plants of the laurel order behave like the dodder.

There can be no doubt that the dodder is a descendant of a climbing ancestor which used its support only as a support. It is interesting to find that it shows two kinds of movements alternating, the twining and the coiling, and it has sensitiveness to contact which is absent from twiners like hops, but present in tendril bearers like peas and vines. The suckers that grow from the dodder into the stem of the clover are to be compared with the aerial rootlets of the Ivy. It is true that in the Ivy the rootlets serve only for attachment, but there are some root-climbers in which the gripping rootlets are also able to absorb water from the tree stem. It is also interesting to find that the dodder has a little of the precious green pigment (chlorophyll) left, and that it sometimes climbs up a dead plant. This is, of course, a fatal thing to do, but does it not give us a hint that the dodder was long ago a climber and nothing more? Is it not a straw that shows how the wind *has blown*?

When we look back we see that the thieving habit may have arisen from more reputable habits:—

Perching on other plants;
Feeding on decay;
Living in close association;
Living in partnership; and
Climbing.

It is safe to say that Nature always rewards vigour and independence, and is always against slackness, against what Browning calls "the unlit lamp and the ungirt loin." At the same time we see that the door to a dependent parasitic life is kept open.

But there is a seamy side to loss of independence. The thievish parasites are apt to degenerate, to drop down the rungs of the ladder of

Photo: A. W. Dennis.

BUTTERWORT (Pinguicula), AN INSECTIVOROUS PLANT OF MARSHY GROUND.

This well known plant has a rosette of plump root-leaves glistening with digestive glands. Small insects adhere to the sticky surface, and the margins of the leaf roll in on them a little. After the products of digestion have been absorbed, the leaf unrolls again. There is a beautiful violet flower. The plant belongs to the order Lentibulariaceæ. The photograph shows several insects caught on the sticky surface of the petals.

Photo: John J. Ward, F.E.S.

GREATER BLADDERWORT WITH ITS TRAPS.

The common bladderwort (*Utricularia vulgaris*) is a submerged water plant, without trace of roots. Small animals, such as Crustaceans, enter the traps and cannot get out again. The products of decay are absorbed by the plant. An upright flower-stalk rises above the surface and bears a beautiful golden flower. In winter the bud at the end of a floating shoot drops off and sinks to the bottom, coming to the surface again in spring.

evolution. There is little hint of this in the mistletoe, for it is only half a thief. There is much of it in the unhealthy leafless dodder, for it becomes a thief altogether. Very strange are some of the plants called Rafflesias, found on the ground in Equatorial forests. Almost the whole plant has sunk back to the level of a fungus, except the flower. This may be the biggest flower in the world, two feet across, but it is a parasitic flower!

Carnivorous Plants.

If a plant could have a feeling of satisfaction, it would have it when it catches an insect, for it is an achievement on the part of a plant—fixed and half asleep—to catch one of the most active of animals. It is a very interesting case of turning the tables, and it occurs, as one would expect, at various levels.

Butterwort.

Common in boggy places is the butterwort (*Pinguicula vulgaris*), with glistening yellowish-green leaves, squat like a starfish on the ground, and with a beautiful violet, somewhat pea-like flower on the end of a four-inch stalk. It is one of the simplest of the carnivorous or insectivorous plants. The leaves are sticky with a secretion from skin-glands; small insects alight and are entangled; the edges of the leaves roll inwards a little; the booty is digested and the results are absorbed.

Bladderwort.

Related to the butterwort, but very different in habitat and appearance, is the bladderwort (Utricularia), which lives in pools on the moorland. It is a floating rootless plant, with many leaves, like tufts of green threads, on the slender elongated stem. There is a golden flower on the end of an upright stalk, but the plant does not flower every year. When winter comes the terminal bud, heavily laden with reserves, drops off the stem and sinks to the bottom. It remains latent through the winter and is buoyed up by gas-bubbles in spring to start afresh on the surface. Thus the bladderwort is almost immortal. Now some of the cut-up parts of the delicate leaves are transformed into very neat traps about the size of the head of a big pin. They are hollow, with a valved door that opens only inwards, and round the door there are slender hairs with some attractive mucilage. Minute Crustaceans, popularly called water-fleas, explore these hairs and push the valved door. It yields before them; they are imprisoned; they die; and the products of decomposition are absorbed by the bladderwort.

Photo: F. W. Bond.

BLADDER OF BLADDERWORT.

The trap or bladder seems to be equivalent to a hollow leaf. When a small animal pushes at the door it yields; but it only opens from the outside, so the intruder is unable to escape.

Photo: W. S. Berridge, F.Z.S.

CHINESE SCALY ANTEATER OR PANGOLIN (*Manis aurita*).

The scaly anteaters or Pangolins of the genus Manis are African and Oriental in distribution. They belong to the order of Edentates, and are distinguished by their overlapping horny scales. Between the scales there are some strong hairs, but these seem to disappear in the adults of the African species. There are only minute traces of teeth. The worm-like tongue is used in ant-catching, and is viscid with salivary secretion which entangles the insects.

Photo : Reg. A. Malby.

PITCHER OF CORONATION NEPENTHES.

Most of the pitcher plants grow in boggy places in warm countries, and eke out the scanty supply of nitrogenous salts by catching insects. The pitcher is usually developed at the end of a tendril, which is prolonged from the midrib of the leaf. It seems that the pitcher develops as an indimpling of the upper surface of the end of the leaf. The lid grows out below the very tip.

There are many different kinds of pitcher plants, some growing like bunches of trumpets out of the ground, as in the American Sarracenias, while others are perched on trees with their pitchers hanging down on the end of tendrils, as in the Nepenthes of Borneo. Over the firm margin of the Nepenthes pitcher there is a lid half open, which keeps out the rain; and this is said to be the very tip of the leaf; for the pitcher is a transformation of the end of a tendril which is formed as a continuation of the midrib of a broad leaf-blade. The pitchers vary from the size of a thimble to the size of a quart, according to the kind. Insects are attracted by bright colouring and by secretions of nectar near the mouth of the pitcher; they enter and are rewarded, but they gradually find themselves on a slippery surface with downward pointed hairs which make return difficult; they tumble into the lower regions of the pitcher, which contains a fluid with digestive juice secreted by glands in the walls; the products of digestion are absorbed. In the Sarracenias there is no digestive juice; the insects decompose and absorption follows.

Pitcher Plants.

Among the bog-moss in the glen and in similar moist places on peaty ground the sundew (Drosera) thrives. There may be very little usable soil, and yet it thrives because of its carnivorous habits. There is a rosette of red leaves, first narrow, then expanded into a spoon, bearing "tentacles," which are short in the centre part and long round the margin. The tip of each tentacle looks as if it carried a dew-drop, but this is a sticky secretion made by the plant. An insect, attracted perhaps by the colour and a slight fragrance, touches the tentacles and becomes entangled. The clear drops serve as insect-lime. Moreover, the tentacles are both sensitive and mobile; they

The Sundew.

Photo : Reg. A. Malby.

SECTION OF THE PITCHER OF CORONATION NEPENTHES.

This pitcher has been cut open. The upper edge best seen above is curved inwards. Below the edge is an area with honey glands; then there are more glands, apparently digestive. Then comes a slippery region, from which the insects, attracted by the honey and perhaps also by colour, tumble into the water at the foot.

Photo: Reg. A. Malby.

NEPENTHES RATCLIFFIANA: A HANDSOME TROPICAL PITCHER PLANT, OF A REDDISH COLOUR EXTERNALLY.

Many of the pitcher plants grow perched on trees, with the pitchers hanging down. The prolongation of the midrib of the broad leaf may be a tendril and twine round a support. But a tendril that does not find a support may develop into a pitcher with digestive juice.

curve inwards on the struggling midge. A message travels in the leaf-blade from one tentacle to another and they all fold in on the victim. What was like an open hand appears like a closed fist. There is more secretion of juice; the smothered insect is digested; the results, along with any surplus juice, are absorbed; and after a while the tentacles unfold once more.

In the sundew the provocation of certain touches and chemicals seems to excite the base of the tentacle, so that it elongates on its outer or lower side, and this makes the tentacle bend inwards. Some would say that the base of the tentacle starts *growing unequally*. After a time an increase in the length of the tentacle-base on the opposite side (inner or upper) causes straightening and bending outwards. In any case, the tentacle moves effectively, and it will not answer back to any and every provocation. It answers the midge, but not the rain-drop.

Related to the sundew there is a small Portuguese shrub called Drosophyllum, with very long narrow leaves covered with tentacles. These tentacles do not move, but their secretion is viscid and numerous insects are caught. It is said that the peasants use it as fly-paper.

Venus Fly-trap.

In many ways the most striking of the carnivorous plants is Venus Fly-trap (Dionæa), which grows in marshy places in Carolina. The leaves are bright in colour and divided into a winged stalk and an oval blade, which is fringed with stiff processes like the teeth of a rat-trap. On the middle of each half-blade there are three sensitive hairs, hinged at the base. When one of these is touched by an insect, the leaf closes, and the marginal teeth interlock. On the imprisoned insect there is poured an abundant secretion of digestive juice. This dissolves the crushed and smothered victim. After the digested products have been absorbed, the leaf

Photo: A. W. Dennis.

WEST AUSTRALIAN PITCHER PLANT (*Cephalotus follicularis*).

The pitchers form a rosette in marshy ground; a little higher up there are flat ordinary leaves, as the photograph shows. Both grow from a prostrate underground stem. An interesting point is that Cephalotus is not nearly related to Nepenthes, though the pitchers are much the same in general structure. Both kinds are admirably suited for attracting, capturing, and digesting insects.

Photo : A. W. Dennis.

ROUND-LEAVED SUNDEW (*Drosera rotundifolia*).

The sundew is common in British bogs. An underground stem bears a rosette of reddish leaves. From the middle of the rosette there rises a flower-stalk with small flowers, which do not usually open, but pollinate themselves. The sundew can live in very poor soil, because it is so successful in catching insects. While it cannot be said that insects are absolutely necessary, they are certainly very beneficial.

re-opens. If the Fly-trap is cheated several times with faked insects it ceases to respond; but it soon " forgets " the trick. Another very interesting point is that when the halves of the blade move (by a collapse of cells along the midrib which forms the hinge), there is an electrical change in the leaf like that which occurs in a contracting muscle in an animal.

The Meaning of the Carnivorous Habit.

These are the most important of the carnivorous plants, and there is no denying that they suggest animals. Thus in the sundew and the fly-trap there is great sensitiveness to certain kinds of provocation and marked movement of parts. In these and in Nepenthes there is copious production of digestive juice. But in every ordinary flowering plant there is sensitiveness, there is movement in the growing shoot and root, and there is a sort of digestive fermentation, e.g., of starch into sugar. In the carnivorous plants these capacities are much more pronounced. The " animal that lurks in every plant " is more restless.

But why should it pay these carnivorous plants to be so animal-like ? The answer is that they find it difficult to obtain enough nitrogenous food in any other way. Boggy and peaty soil is very difficult to live in, and though sundews and the like do not die if they get no insects, they thrive better and produce more seed if they are allowed to capture their prey as usual. It need hardly be said that the insect's body, when digested or even decomposed, provides abundant nitrogenous food. Similarly for the others : Sarracenias live in bogs, the Nepenthes are often perched on trees, the Bladderwort floats in the water of the moorland pool, the Butterwort grows in marshy places. In short, where nitrogenous salts are scarce these adventurous carnivorous plants have found a way out.

XXVI

CLIMBING PLANTS

THERE is probably no characteristic of the plant that one may not find in some animal. Thus most plants have chlorophyll; so has the green species of Bell-Animalcule (Vorticella). We do not count those animals like the Green Hydra, which owe their green colour to minute partner-plants. Almost all plants have cellulose, which forms the framework of their cell-walls; it also occurs in the tunic of the sea-squirt or Ascidian.

Similarly one may say, but more guardedly, that most of the characteristics of animals find some expression among plants. Good examples are to be found in the exquisite touchiness of the Sensitive Plant, the jerky movements of the Indian Telegraph Plant, and the digestive juice of the insectivorous Sundew. The animal lurks in the plant, and this is one of the reasons why climbing plants have a certain fascination. So many of them have a life-long possession of the mobility which all young shoots show—bending and bowing to the different points of the compass; so many of them have a sensitiveness to contact far finer than that of our finger-tips; so many of them show what looks like endeavour—*as if* they were trying to reach sunshine and fresh air. And that is why we include climbing plants here—they illustrate the quest for food.

§ 1

The simplest kind of climbing is that illustrated by Jack-run-the-hedge, or Cleavers, which insinuates its long and slender stems among the crowded branches of the neglected hedgerow, and scrambles up. It is helped to grip by the stiff whorls of leaves and by the backward

Scramblers.

Photo: John J. Ward, F.E.S.

PART OF THE COMMON SUNDEW WITH A SMALL CATERPILLAR.

The leaf is covered with delicate tentacles with swollen heads, shown black in the photograph. A tentacle is very sensitive to touch and bends the head inwards and downwards. The head then secretes the digestive juice and the results of digestion are absorbed by the leaf surface. A message travels in the leaf from one stimulated tentacle to another.

Photo: John J. Ward, F.E.S.

JACK-RUN-THE-HEDGE (*Gallium aparine*).

This common hedgerow plant has many names, including goose-grass and cleavers. The last name refers to the way the prickly fruits adhere to passing animals or to our clothes. The rapidly growing stem scrambles among the twigs, and this rough-and-ready climbing is helped by the numerous reflexed hooks covering the stem. Jack-run-the-hedge is one of the bedstraws (Gallium) with leaves in whorls and minute flowers.

bramble, and by the side of a disused roadway we often see it running over everything and sometimes becoming so luxuriant that it weighs down its supports and both sink to the ground in a disorderly tangle.

What is seen on a small scale in the hedgerow is seen magnified in the tropical forest. Thus the Rattan Palms, often called Lianas or Lianes, have long lassoes, which bear sharp outgrowths, sometimes like fishing-hooks. The wind sways these lassoes about —they may give an explorer a very bad wound —and they get fixed in the branches of the stronger trees. It is a rough-and-ready kind of climbing, but the Rattans manage to scramble up by roundabout paths. They are often much longer than the height of the tree which supports them. In extreme cases a length of 600–1,000 feet has been measured. In most climbing plants there must be an inborn tendency to elongate, and this is probably favoured by the relatively dark surroundings of dense vegetation, as in the tropical forest. It may be noted that when a liane sends its lasso right round a branch and tightens this in the course of further growth, it may strangle the branch by constricting the younger tissue in which the sap flows. Thus the liane often kills its support, and its success in reaching light and air is only temporary.

bent prickles, which remind one of the tips of crochet needles. This scrambler is very sensitive to the influence of light, always bending towards it; and this is partly because the less illumined side grows more quickly. In an automatic way Jack-run-the-hedge gets more and more of itself into the sunlight and fresh air, rising on the shoulders of its neighbours. Another successful scrambler or straggler is the

It is interesting to inquire into the nature of the hook-like grappling organs, for it turns out that very different parts of the plant may be

transformed in the same way. The hooks may appear on the greatly elongated tip of the midrib of the leaf; or they may be made out of leaflets or stipules (basal parts of a leaf); or they may be buds that do not succeed in becoming shoots. This sort of question is always worth asking, for it gives us a glimpse of one of Nature's ways—one of the methods of evolution—making a new thing out of an old thing.

As to the hook-bearing lassoes of the climbing palms that have been referred to, they are usually due to a lengthening out of the midrib of a leaf, or to the transformation of an entire shoot into what might be called a flexible harpoon. Some of these lassoes are actually three to six feet in length.

§ 2

Root-Climbers.

The word "root-climbers" is almost like a contradiction in terms, for the proper place of a root is in the ground. Perhaps a better name would be "Adhesive Climbers." In any case, everyone knows a good example—the common ivy. If we pull a piece off a wall or a tree we disclose a multitude of small finger-like adhesive roots. They hold on so firmly that they often break off the ivy rather than let go their hold of the support. The reason for their holding on is not so easily seen; they have numerous microscopic root-hairs, which grow into the microscopic crevices. When the surface of the support is very damp, the ivy develops a larger number of root hairs and takes a very firm grip. According to Darwin, the climbing roots of the Creeping Fig exude a sort of glue, which enables them to adhere even to the smooth surface of glass.

The climbing roots so familiar on the ivy stem have lost the true root's inborn tendency to seek the earth, but they have a very strong tendency to grow away from the light, so they grow out on the darker side next the support. Experiments have shown that an ivy shoot growing in a dimly lighted space, with no more light on one side than on any other side, will give off adhesive roots all round. In ordinary cases the reason for the ivy's adhesive roots hugging the wall or the tree is simply—if one dare say "simply"—that they are by nature light-avoiders ("negatively heliotropic"), just as some animals are. But in some other root-climbers the adhesive roots have a second obligation forcing them to press into their support—they are sensitive to contact.

Photo: A. W. Dennis.

IVY, SHOWING WALL ROOTS, AS THEY GROW WHEN THE STEM IS ORIGINALLY CLOSE TO ITS SUPPORT.

The climbing roots of the ivy, which bind the stem to its support, are outgrowths from the stem, unconnected with the true root system. On the clinging portion of the stem the leaves are lobed; where the stem projects freely, open to the light, the lobes disappear.

Photo: T. Dobson, F.E.S.

GARDEN PEA, WITH CLIMBING TENDRILS.

The tendrils of the pea are transformations of the tips of two or three of the leaflets composing the pinnate leaf. They illustrate the power of movement and exquisite sensitiveness to contact. The curvature is towards the side touched and thus the tendril surrounds the twig.

We must linger over the aerial roots of the ivy because of another peculiarity. They are purely for fixing purposes, and they cannot normally absorb moisture, though it is said that they sometimes regain this absorbing function, so characteristic of roots, if the substratum to which they are attached is kept continuously very damp. But when the forester cuts through the base of the ivy stem the leaves soon wither away. This shows that the fixing roots of the ivy do not usually absorb anything.

There are many tropical root-climbers, like some of the figs, peppers, arums, and orchids. And some of these have two kinds of aerial roots, those that serve only for fixing, and those that are also able to absorb. This enables us to understand how it is that some root-climbers in the forest can continue to flourish though they have lost their connection with the ground. They are absorbing rain-water from the surface of their neighbours.

A third group of climbing plants is that of the Twiners, which coil around their support. They are familiarly illustrated by the hop, which twines its stem in the direction of the hands of a watch (right-handed), and by the convolvulus and scarlet-runner, which twine in the opposite direction (left-handed), as is commoner. In the poisonous Bitter-Sweet of the hedgerow—really a twining species of

Twiners.

Photo: A. W. Dennis

PASSION FLOWER (*Passiflora cærulea*), SHOWING THE DOUBLE-CORKSCREW SPIRAL

The tendril in this beautiful plant is a transformed branch, growing out from the axil of a leaf. After fixation there is a spiral coiling of the part between the attachment and the base. As both ends are fixed, a reversal of the spiral must come about, making a spring anchor.

Photo : A. W. Dennis.

WHITE BRYONY (*Bryonia dioica*). A GOOD EXAMPLE OF A TENDRIL CLIMBER.

The tendril in this hedgerow plant is probably a transformed branch. It grows out beside a leaf, and curves round a twig that it touches. Then the long portion between the base of the tendril and the support twists into a double-corkscrew which yields without breaking in the storm.

potato—the coiling is sometimes in a right-handed, sometimes in a left-handed, spiral.

What happens when a hop-plant twines? This is a very difficult question to answer and authorities are not agreed. The end of the shoot is at first straight up in the air. Then the uppermost portion bends till it lies almost horizontally. As it goes on growing it swings round in a circle, and turns also on its own axis. Some say that the circular movement can be interpreted as due to the influence of the earth acting on the growing shoot; others say that the cause is in part at least within the hop itself. In any case, the swinging round increases the shoot's chance of touching a support. When it does this there is a cessation of movement below the point of contact. The free part grows on and may touch the same support or another, and again there is an arrest. If no support is found, the hop sprawls on the ground.

Tendril-Bearers.

The finest climbers are the Tendril-Bearers, such as the bryony, the vine, the passion-flower, and the garden pea. They have a special organ—the tendril—set apart for climbing. As the delicate tendril grows, like an ever-lengthening finger, its tip describes leisurely circles. These movements may bring it into touch with a twig or some other support, and the tendril is exquisitely sensitive to contact. It answers back even to a thread. The side away from the surface of contact grows more quickly than the side which is touching, and so the tendril twines round and round its support till the free part is used up. The next steps in the climbing are clearly described in Dr. MacGregor Skene's admirable "Common Plants" (1921). "The coiled part hardens and becomes woody, clasping the support firmly. The long straight portion, between the support and the base of the tendril, twists into a tight corkscrew, reversed once or twice—for a thread fixed at both ends cannot be forced into a spiral without at least one reversal in the direction of the twist—and then becomes woody."

In the Virginia Creeper the tendril is a transformed shoot, as it is in the grape-vine, but it reaches to a higher degree of efficiency. It branches, and the tips of the branches seek the shade. They expand into tiny discs, they secrete a glue. Thereafter the tendril may become woody and contract into a spiral spring. This is perfection.

Darwin noticed that after a stormy night, during which many plants were battered, the Bryony on the hedge was uninjured. Its coiled tendrils were like anchors with springs; they yielded a little when gusts came, but they did not break.

The True Inwardness of Climbing.

One must not think of there being any order of Climbing Plants. Over and over again the climbing habit has arisen in orders that are not related to one another. It is the answer-back that a certain kind of plant-constitution makes to the difficult conditions of a crowd, as in the tropical forest, the jungle, and the hedgerow run wild. In such places some plants are shade-lovers, like the Enchanter's Night-Shade (Circæa) or the beautiful little Moschatel. Others have become thievish; others have joined hands with fungi as partners. But a better answer is climbing, for it brings the plant out of the crowd into the sunlight and fresh air.

Climbing Plants may be thought of as plants with an inborn tendency to grow lanky, and to retain a certain youthful mobility and sensitiveness. For all young shoots exhibit growth-movements, their tips describing little circles or ellipses. Experiments have shown that in semi-darkness non-climbing plants may develop a tendency to scramble towards the light; so it is possible that the peculiar "*nurture*" afforded by the shade may help the inborn "*nature*" of the plant to grow long and to be mobile.

XXVII
MAKING STORES

THE storing instinct is found in varying degrees among many different kinds of animals. As we should expect, it does not reach its highest expression among flesh-eaters and insect-eaters, since any provision they can make for lean times would only be of use for a few days ahead. Yet the instinct to hide whatever cannot immediately be eaten is common among them too, even where there is no danger of scarcity. We all know that the domestic dog, which depends almost entirely on his master for food, will carefully bury the bone that he does not want to eat at the moment.

The fox that is fortunate enough—from his point of view!—to find an unsecured poultry house, will carry off as many hens as time permits and bury them all round his earth, to be consumed at leisure if the succeeding nights are less lucky.

§ 1

The Weasel Again.

This storing of fleshy food is carried to an extreme by that active and insatiable little hunter, the common weasel. As we have seen, he has a veritable passion for hunting, indeed, a lust for killing. The weasel generally confines himself to a particular range for a time, and he will hunt that range

Photo: W. S. Berridge, F.Z.S.

SECTION OF A FEMALE MOLE'S NEST.

A large mound of earth, badly called the "fortress," is made by the mole as a centre for its winter operations and rest; there are tunnels radiating out in an irregular fashion. But the female makes a specially large mound for breeding purposes, and this has a very simple structure, as the photograph shows. The three to six young ones are born naked and blind; but they grow with great rapidity and are able to burrow in five weeks.

Photos: F. W. Bond. THE CHEEK-POUCHES OF A BABOON (Cynocephalus).

In many Old World monkeys with their nostrils close together (Catarrhini), there are two cheek-pouches in which food can be stored. Each pouch opens into the mouth by a slit just behind the angle of the lips. The full pouch protrudes prominently under the lower jaw.

Photo: W. S. Berridge, F.Z.S.

PRAIRIE MARMOT AT THE ENTRANCE OF ITS BURROW.

The prairie marmot (Cynomys) is a burrowing rodent, often called the prairie dog because of its barking cry. But its voice is more like that of a toy-dog. They make great burrows in desert-like regions in North America, and live in immense and very lively colonies. Over 7,000 burrows have been counted in about a square mile in Arizona. They destroy grass and many other plants. They have small cheek-pouches, and they sometimes store in their burrows.

eagerly in every direction, above ground and below, until he has almost exhausted its possibilities. He does not eat nearly all he kills; he hides and buries carcasses all over his range; but he seldom, if ever, goes back to look for them, for he likes warm blood, and the excitement of the chase. Moreover, he is not nearly so liable to periods of scarcity as many other mammals. His bill of fare is very wide. He likes game-birds, young rabbits and hares, but if he cannot get these there are plenty of smaller creatures to be had. He does not readily climb trees to catch birds in their nests, as his larger cousin, the stoat, does, but his smallness enables him to pursue the field-mice and voles through their runways, and his keen sense of smell leads him unfailingly to their nests of young ones.

Thus the weasel, which has exhausted one hunting-ground, will leave it "dotted all over with '*caches*,'" seek out another, fight for it with its tenant if it has one, and begin afresh. That his instinct is to *store*, and not merely to hide, his prey is shown by the fact that he will gather the rats he has killed into heaps under the floor of the barn, and he has been known to put five young larks safely away in a crevice, which he never revisited.

It seems quite reasonable to suppose that this storing instinct has been handed down from a time when the climate was more severe, with more continuous frost and snow, when therefore a newly-killed carcass, hidden just under the surface of the ground, would remain fresh for a long time. It is on record that the dogs accompanying the naturalists who dug up a 1,000-year-old mammoth from the frozen earth in Siberia, fell upon the flesh and ate it as eagerly as if it had been recently killed. And do we not ourselves use "cold storage" as a method of carrying our meat from the ends of the earth? Possibly, too, the instinct which was of use at one time, has gone a little too far, as instincts are known to do.

§ 2

The Mole.

Among insect-eating mammals the one to which storing habits are most generally attributed is the mole. His food consists mainly of earthworms, full-grown insects, and grubs, and he requires an extraordinary quantity, for he eats about half his own weight every day. In captivity, if he is left unfed during the night, even after a good supper, he may be found dead, with no remains of food in his stomach, in the morning. So it would not be surprising if the mole had learnt to provide against even temporary scarcity. It is said that before the beginning of winter the mole gathers great numbers of earthworms and stores them in the enlarged chamber at the end of his run, having first taken the precaution of biting off their heads, so that, though they will remain alive, they will not be energetic enough to creep away. Large clusters of torpid and wounded worms have certainly often been found in the burrows, and the mole undoubtedly eats them, but nobody has ever seen him put them there! Many naturalists believe that it is the worms themselves, often damaged, and always nearly

Photo: W. S. Berridge, F.Z.S.

AMERICAN GREY SQUIRREL (*Sciurus carolinensis*), SHOWING ITS ATTITUDE WHEN EATING.

A native of Eastern North America and Southern Canada, introduced into many parts of Great Britain. It is a friendly and charming creature, but there is reason to fear that it may become too common. It has a wide range of appetite and is certainly not welcome to the forester.

Photo: F. W. Bond.

GREY SQUIRREL BURYING A NUT.

On the approach of winter the grey squirrels begin to lay up nuts and seeds in holes in the ground and in trees. There are many of these caches, and sometimes a single nut is buried. Careful observation has shown that an underground store can be detected even through a covering of snow. The storing is mostly done by day, but it may be continued in the moonlight, and the industry of the creature is admirable.

benumbed with cold, that congregate in these convenient holes, and more observation is needed on the point. We are told that a captive specimen would, when its hunger was for the moment satisfied, take a worm from the hand, bite it all along till it was nearly, but not quite, dead, bury it, and come back for another, which it treated in the same way. Recently, too, there have been fresh observations made which seem to show that the mole does the collecting of the worms; but even if he does it is a very temporary expedient, for the biggest cluster ever dug up—a large spadeful—would not keep a mole alive for more than two or three days!

§ 3

Storing Among Vegetarians.

It is among the animals that eat fruits, seeds, nuts, and other plant-food that we can best study the storing habit. And this is not surprising, because these foods are readily available only for a part of the year, so that in northern countries an arrangement of some kind for tiding over the winter is essential.

Many monkeys are provided with cheek-pouches, which they quickly stuff as full as possible, but this is only a device for securing all that they can before they are disturbed; it is not storing, for which, as their home is in the tropical forests, they have no need.

Among the rodents or gnawing animals storing occurs in varying degrees. Perhaps we may see the very beginnings of the habit, and guess at how it was learnt, in the marmots of the Alps. Several marmots together dig a large burrow in autumn and drag into it great quantities of grass to line it comfortably. Then they creep into this nest, close up the narrow entrance with a bundle of grass, and sleep the winter away. When they wake up they nibble at the now dried lining of the nest until they have recovered strength sufficiently to issue forth in search of fresh food.

That is an accidental sort of storing, but many other rodents do it deliberately. As we all know him so well, let us take the squirrel as an example, though he is by no means one of the most methodical of storers.

§ 4

The Story of the Squirrel.

The Red Squirrel is very common throughout Great Britain, though in Scotland it was almost entirely driven out about a century ago by the persistent cutting down of the forests. But it was reintroduced at various points, simply because of its beauty and its fascinating ways. Year by year it became more abundant, until in some wooded districts it could be only regarded as a "pest," and measures had to be taken for its destruction. But we need not here dwell upon this aspect of things. The life of animals as it affects man is an interesting and very necessary study, which will be discussed in a later chapter of this book. But it is not the whole of Natural History! If we are really to understand the life of wild animals, we must learn to look at it from their point of view and not from our own.

And what a jolly life the squirrel's must be! What fun he seems to be having as we watch him running up the trunk of a tree, peeping out at us from behind it, waiting till we come near, and then running out to the end of a branch, springing lightly across a space to another one, and disappearing among the dark pine-tops. And how pretty he looks as he sits erect, his tail turned up behind him, at the foot of a tree, holding a bit of toadstool in his deft forepaws, and daintily tearing bits off it with his teeth. Sometimes he prefers to take his meal on the top of a log or a flat stone, and there he sits, his bright eyes watchful, his whole body alert, skilfully pulling off the scales from a fir-cone to get at the palatable seeds. At the first hint of intrusion he drops his half-eaten cone on his already littered table, and is away like a flash to the nearest tree.

Most charming sight of all, but not so easily seen, is a mother squirrel carrying her baby carefully in her mouth across a stretch of grass between one belt of woodland and another. She is transferring her family, one by one, from the comfortable "drey," where they were born and suckled, to a new home less exposed to danger, or, it may be, nearer to an abundant food-supply. She will have to make from five to eight journeys before she has finished her "flitting," and, as all that survive of these young ones will be ready to have families of their own the following spring, it is little wonder that squirrels may become too numerous in the woods. It should be noted that there is not a little education of the young squirrels by their parents; they are taught gymnastics and the long alphabet of woodcraft. The squirrel's main food is the seeds of pines, acorns, beech-mast and hazel nuts, but in spring he bites the young buds off the larches and he gnaws the bark of the young tree-tops in a ring to get at the sweet sap flowing downwards underneath. As he bites right through the bark and into the young wood the ascending sap, which goes up that way, is checked in its progress and all the tree above the ring must die. For the ascending sap contains the quite

Photo: F. W. Bond.

RED SQUIRREL; BOHEMIAN VARIETY.

This is a near relative of the common British squirrel, with a heavier tail. As winter approaches, it has a rich nut-brown colour, and the ears begin to show tufts. In spring the winter-dress is considerably worn and faded. The new summer coat is redder and shorter.

Photo: F. W. Bond. FLYING SQUIRREL, (*Sciuropterus volucella*).

This North American parachutist has a fold of skin along each side of the body and extending to the wrist and the ankle. It can glide or plane from tree to tree for thirty or forty yards. It is a playful creature, about six inches long in body, with a tail about the same.

Photo: F. W. Bond.

VULPINE SQUIRREL, (*Sciurus vulpances*).

The American fox squirrels are about twice the size of grey squirrels. The colour is often rusty or still darker. They hunt for food on the ground as well as on trees, and they make great stores for the winter. They become fatter than most of their relatives, and their flesh is palatable.

indispensable soil-water and salts on which the plant depends.

Like most rodents, the squirrel will take animal food if occasion offers, and, as we noticed in the chapter on " Linked Lives," he eats both the young and the eggs of wood-pigeons, and thus to some extent gives back to the farmer what he takes from the forester. Unfortunately he robs the nests of singing birds as well.

Towards autumn the squirrel begins to gather stores of nuts, acorns and the like. Some of these he hides in his hole near the foot of his favourite tree, and these will satisfy his hunger when the weather is wet, or the frost very severe. He does not sleep through the winter, but he often remains in his hole for two or three days at a time. He is sometimes drowsy, but he is not a true " winter-sleeper."

Other stores are buried in many different places in the flat ground or on a bank often at some distance from the nest, and these are so carefully covered over that it is often thought the squirrel can never find them again. Mushrooms and toadstools are gathered but not buried, for they would very quickly decay in moist soil. They are carried up into a tree and firmly stuck into a cavity, or into a fork between branches, where they will remain quite dry. So the squirrel puts brains into his storing.

The squirrel is apt to be very wasteful in his methods, and "will destroy a whole bush for the sake of half a dozen nuts." Two squirrels were observed working busily at a copse of beechwood, going out very nearly to the end of quite thin branches, where they hung by the hind legs while they stripped off nut after nut, many of these falling to the ground, more or less lost spoil. Squirrels often engage in this work-play for hours, for they are untiring.

Photo: F. W. Bond.

FOUR-BANDED CHIPMUNK (*Entamias quadrivittatus*).

The chipmunks are American rock-squirrels, small in size, graceful in form, very pert and quick. They are fond of saying "Chip, chip, chip, chip." In autumn they store large quantities of grain and nuts. They have capacious cheek-pouches, in which they carry their booty home.

An American observer watched the Grey Squirrel —a near relative of our red one and now threatening to oust it in some parts of England—bringing down nuts one at a time in his mouth. He scraped a hole about two inches deep, dropped in his nut, pressed it firmly down with his forepaws, covered it with earth, and pulled the grass over the spot, so that no trace of his work was visible. But the same observer saw squirrels running about over two inches of snow in winter. From time to time one of them would suddenly stop short, begin to scrape, and then "dig up a nut with unfailing precision." So the squirrel may not be so happy-go-lucky as he seems. He knows that he can trust to his very delicate sense of smell to guide him to the numerous stores he has laid up. It is interesting to remember how the Northern people believe the reindeer can "smell by his feet," for it shovels off the snow at profitable places. But it smells by the nostrils as usual.

There is something unusually attractive about the squirrel. It is petite without being pigmyish; the bushy tail balances the body; the rich brownish-red upper colouring is very pleasing; its alert attitude when watching you is prepossessing; its table manners are perfect as it unshells the kernel of the nut, and, as MacGillivray observes, "even removes the outer pellicle before munching it." But the movements take our breath away, we do not know whether to admire most their gracefulness or their daring.

In the summer we startled one as it was eating a nut or perhaps a toadstool; it covered the ground in a succession of leaps so quick that we could only see the result; it ran up the tree as

Photo: F. W. Bond.

WHITE-SPOTTED SQUIRREL, (*Funisciurus leucostigma*).

A thick-tailed squirrel from the Gold Coast.

Photo: Hans Herzberg.

A FAMILY GROUP OF HAMSTERS (*Cricetus frumentarius*).

The hamster is an Old World rodent, about eight inches long, with a short tail. It collects food in its cheek pouches, and before winter comes it makes a great store in its burrow. It passes into a state of winter sleep or hibernation. The cheek-pouches are enormous.

if it did not need to hold on; it vanished to the other side, and looked round at us; and as we came near it ran along a branch, on to the very end, and then it was on another tree. If need be, it can remain quite motionless, pressing its body against the trunk. When it sleeps it uses its tail as a blanket.

Apart from man, who naturally resents the way the squirrels bark the trees or eat off the topmost shoot, these attractive creatures have few enemies, for it is rarely that a stoat or a hawk gets even a youngster. This security probably adds to the natural gaiety of their disposition, and there are few animals that give us a stronger impression of the joyousness of life. They recall Walt Whitman's lines:—

"They do not sweat and whine about their condition. . . .
Not one is respectable or unhappy over the whole earth."

If tamed when young, they make delightful pets, especially if they are allowed to come and go, which should, indeed, be a condition of keeping an animal so instinct with freedom. Squirrels are among the playing animals, and have many a game of "tig" on the trees. We do not suppose that they are very clever—their brain does not point in that direction—but they are charmingly joyous.

§ 5

Other Storers.

The hamster of Central Europe, a rodent about the size of a rat, digs out a large storing chamber beside the burrow in which it lives, and fills it with grains and seeds of all kinds. When one chamber is full he covers it up and hollows out another. He may have made three or four by the time the cold weather sets in, and then he blocks the tunnels leading to his burrow, and lives on his stores throughout the winter. Burrows have been found the contents of which weighed from 20–25 lbs.! To collect 20 lbs. weight of grains of corn must be a formidable task, but the hamster has a special provision for the work. He has internal cheek-pouches, something like those of certain monkeys, but so large that they reach back almost to the shoulders. When he finds animal food he eats it on the spot, but when he finds seeds he packs them into his pouches

and carries them to his burrow either to eat there or to store. His way of dealing with corn, we are told, is to cut the stalk and pass the ear through his mouth two or three times. The grains spring out, and with his tongue he presses them down into the cheek-pouches.

The common little long-tailed field-mouse or wood-mouse has the same habit of making a special storing chamber, to which it carries peas, grains, and seeds of all kinds. Sometimes the same burrow contains several mice, and they all take part in the collecting of stores. The field-mice do not sleep through the winter, but they remain for the most part in their burrows.

This field-mouse has an interesting habit of making temporary stores inside the disused nests of blackbirds and thrushes. These stores are usually rose-hips, which the mice appear to gather from the bushes. When the nest is filled with hips, a part of its lining is usually dragged over the top for concealment. A field-mouse has even been seen to climb up a hedge carrying an acorn in its mouth to put into this hiding place. When the mouse wants to feast he sits in the middle of the nest, biting off each end of the hip to get at the seeds, from which he extracts the kernels! The red outer skin is not eaten but left in the nest. Within such a nest, well hidden in the midst of a leafy bush, the mouse is safe from his worst enemies, the birds of prey overhead, and the weasels on the ground.

Another device the field-mice have adopted that secures them both food and relative safety in winter, is to make their way far into the tunnels leading to disused mines and the like. There they feed on the moths and other insects which seek out such places in thousands to lie torpid during the winter. But this is an unusual habit. The field-mice are naturally plant feeders, and they carry seeds and fruits to their underground granaries. In so doing they are making use of the stores the plants have built up as a provision for the seedlings of the next generation. But there is enough for all, and many of the seeds that the mice scatter about their runways are quite well placed for germinating, and so giving rise to a new life.

Some of the numerous American field-mice and wood-mice rob, not the stores for the next generation, but those the plant has laid up for its own use—its underground stems or its fleshy roots. Some of these mice—in the group known as the pocket mice—have *outside* cheek pouches with openings at the angles of the mouth. These are lined with hair and do not communicate with the mouth at all, but are used solely for

Photo: G. Hearn.

LONG-TAILED FIELD-MOUSE USING THE DESERTED NEST OF A BLACKBIRD AS ITS STORE CUPBOARD.

This common mouse, technically called *Mus sylvaticus* or *Apodemus sylvaticus*, frequents hedges and fields in summer, stackyards in winter. It eats corn, seeds, nuts, bulbs—almost anything. It does not hibernate, but it makes stores in burrows and nooks, occasionally in a bird's nest.

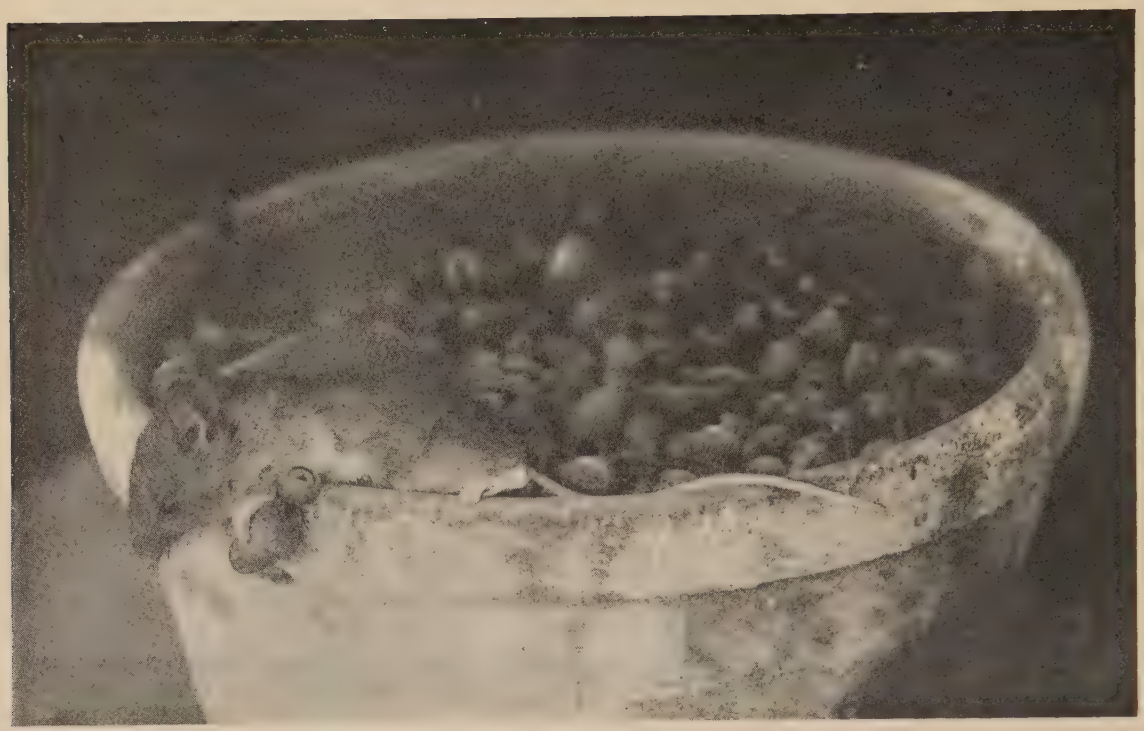


Photo: John J. Ward, F.E.S.

LONG-TAILED FIELD-MOUSE STEALING AN ACORN FROM A TUB IN AN OUTHOUSE.

In summer and autumn this common mouse makes stores for the winter, on which it falls back when the weather is severe, but it rarely ceases to forage. It does much damage in the farm and the garden, especially when its numbers have greatly increased through the destruction of its natural enemies, such as hawks and weasels.

carrying the food collected. The stems or roots are cut into short, neat sections, which are pushed with a deft movement of the fore-paws into the pockets. When both are full, the mouse retires to its burrow and pushes the contents out by pressing from behind with its fore-paws. Three quarts of morning-glory roots have been found in the storeroom of a single mouse.

The pocket gopher, a larger American gnawing animal, has very big pouches, and as he is also very industrious, he may quickly destroy a whole row of young fruit trees by tunnelling under them, and carrying away their roots, cut into short lengths, to provision his own larder for the winter!

§ 6

Storing, in Birds.

The storing habit, that is, external storing as distinct from merely filling the crop, is very rare among birds. Many birds of prey kill a great deal more than they can use at a time, and leave the bodies of their victims scattered about their nests. The eagle-owl carries this to such an extent that the peasants of the district are said to visit the nest regularly in search of such dainties as game-birds, hares and the like.

Some sea-birds, particularly the Gannets, carry home a great deal more fish than can be eaten even by their ever-hungry young ones, and half-digested packets—for the fish are swallowed when caught, and brought up again later—are found lying about the ledges on which they have their homes. It is suggested that they may fall back on these on stormy days when the sea is so rough that all the fish have retreated far below the surface. But this provision would only last for a very short time, and the sea-fowl suffer very severely in a prolonged spell of bad weather.

The shrikes have the curious habit of carrying young birds, mice, lizards, beetles and all sorts of insects to a "larder" in a thorn-bush, and impaling them on the thorns, to be eaten later. One shrike may make several such larders in different bushes near its nest. Various reasons have been suggested for this curious habit, which has already been alluded to in the chapter dealing with carnivores. It may be that they

Photo: Reginald Gaze. MALE SHRIKE BRINGING HUMBLE BEE TO THE NEST.

The rough nest of the red-backed shrike (*Lanius collurio*) is usually hidden in a hedge, but often betrayed by the conspicuous guardian male. The young birds are well fed, mostly with insects, and develop very rapidly. The photograph shows the grey crown and nape and the black frontlet running from in front of the eye to the ears.

Photo : Reginald Gaze. YOUNG SHRIKE EJECTING FOOD PELLET.

The adult shrikes feed on insects like beetles and on small birds and mammals, often impaled on thorns for convenience of eating. The nestlings are fed on insects or on pieces of larger animals, and there is much indigestible material to be ejected, such as the bones of mice.

are preparing for young ones nearly ready to hatch; it may be that their bills are better suited for dealing with their prey when it has softened and is more easily pulled to pieces. Or it may simply be that they like the flavour of flesh "well-hung"!

The storing of seeds is not quite unknown among birds, though it is very unusual. Two species of woodpecker in America live all the summer on grubs and insects. But while they are thus feeding on flesh-food they pick up acorns and store them in a tree—one species pressing them firmly into a hole it has itself bored in the bark, the other packing them one by one into the hollow flower-stem of the agave tree. It is not quite certain whether the birds later eat the acorns themselves or only the grubs that develop within them.

§ 7

Storing, in Social Insects.

The storing habit reaches its perfection among the social insects. Certain members of the beehive do the work of collecting and storing by which the whole community benefits. The storing habits of the ant have been praised from very early times. The ant, "which, having no guide, overseer, or ruler, provideth her meat in the summer and gathereth her food in the harvest." And the naturalist, Aelian, writing in the time of Hadrian, describes their way of setting about it. "Ants pry in troops about threshing floors, some go to collect, others to carry away the burden, and they make way for each other with great politeness, especially the unburdened for the weight-carriers. . . . The larger ants ascend the stalks and gnaw through the grain, the younger stand below, peel off the chaff, and carry it away." But Mr. Moggridge, who studied the habits of the harvesting ants of the South of Europe, tells us that the ants carry the grain to their nest, and there the husk is peeled off and carried outside again. He found in some nests "long, almost cylindrical galleries, which, from the presence of large quantities of shining, black amaranth seeds, looked like trains of gunpowder ready for blasting." The seeds and grains do not germinate within the nest, but, before being used, are carried outside into the rain and allowed to sprout, and thus the seed-coats are burst and the starch of the grains is converted into sugar. The ants then bite off the sprout and allow the seeds to dry again in the sun. It has more recently been shown that by some species of ant the dried seeds are carried back into the nest, chewed into a soft paste and then dried again like little biscuits, in which form they are stored in the granary till needed.

XXVIII
ANIMAL WEAPONS

Struggle and Endeavour.

A LIFE worth living always means some struggle or endeavour. The plant has least of it for it has inexhaustible food supplies in the air and the soil-water, and its green leaves are "traps that catch sunbeams." Yet has not the plant to *assert itself* against the cold, against the drought, against the night, against its neighbours that tend to overgrow it? Perhaps the plant does not thrust against unfriendly influences, but it parries. Deep in the heart of the living creature there is the power of answering back effectively, so that its life is preserved. Among animals this is much more marked; they thrust as well as parry. One does not suppose that the heat of the sun, the frost of winter, the breakers on the shore, the sandstorm in the desert, and so on, are *unfriendly* to animals. That is a word that doesn't fit. But animals have to struggle against them, and when we come to discuss animals in their homes from Pole to Pole we shall see how interesting that kind of struggle is, and how intense—as Tennyson saw so clearly:—

"For life is not as idle ore,
But iron dug from central gloom,
And heated hot with burning fears,
And dipt in baths of hissing tears,
And battered by the shocks of doom
To shape and use."

Photo: M. H. Crawford.

POISONOUS TOADS (*Bufo vulgaris*). ITALIAN SPECIMENS.

Although the toad cannot spit poison, it has numerous poison-glands in its skin. These secrete a somewhat cream-like fluid which contains a strong poison (*phrynin*). Behind the eye of the common toad there is a large swelling, the parotoid gland, from which visible drops of the poisonous secretion ooze out. The poison makes the toad's skin unpalatable, and thus saves the animal from many of its enemies.

The chief reasons for the struggles of living creatures are four in number :—

In the first place organisms or living creatures tend to multiply so rapidly that there is no room or food for them all.

In the second place, the plan of Nature is a chain of reincarnations, the higher forms eat the lower, and the lower forms (among animals) often struggle against being eaten.

In the third place, a vigorous organism is self-assertive, a bit of a hustler, sticking out its elbows in the crowd.

In the fourth place, outside conditions are often changeful, and living creatures must struggle to keep their foothold.

In early days man had to struggle with wild beasts, and for a long time he must have found "discretion the better part of valour," for he was not strong compared with a lion, or swift compared with a panther. His only weapons, to begin with, were sticks and stones, and he had no armour save a skin shield. His safety was in his wits.

Weapons.

It is likely that he would pick up some ideas from watching his rivals, for he might notice that some beasts of prey lay in ambush, that others posted sentinels, and that others found strength in union. It is also very probable that he got hints from animals in regard to weapons, and that he imitated horns and claws, teeth and stings. In fact we know that early man used parts of animals in fashioning some of his weapons. Thus the story goes that Ulysses was killed by a fish-bone, and when we inquire further into the matter we find that this was a sharp-toothed spine that one of the Sting-rays (Trygon) bears near the end of its tail. The Sting-ray is a near relative of the skate, and when it lashes out with its tail it can give a terrible wound. The Sting-ray's spine would obviously make a very formidable spear-head. We suggest that it would be an interesting exercise to make a long comparison between man's weapons and those of animals. Some very strange things would be discovered. Thus there are Bombardier-Beetles which answer back to molestation by expelling from their body an irritant substance, which explodes in the air

with a distinct report—thus coming very near the horrible modern device of poison gas. But one Bombardier-Beetle does not use its poison on another.

Poisonous Backboned Animals.

A fisherman sometimes comes to the surgery with a poisoned hand which has become steadily worse under his own rough-and-ready treatment. He says he got the wound when disentangling from the net a kind of fish called the " weever," and so it often is. There are two British " weevers " which make a poisonous fluid in connection with a spine on their gill-cover and five or six spiny rays on their anterior dorsal fin. In the case of the gill-cover spine there is a deep groove on the upper and lower surface, and along each groove there is a pear-shaped solid mass of poison-making cells. As there is no duct it is probable that some of the cells are burst when the tip of the spine is forced into the skin of the assailant or intruder. When the fish is provoked it raises the first dorsal fin, which is of a deep black colour, and some naturalists believe that this is a way the fish has of impressing other animals with its poisonousness. It says *Noli me tangere*, " Don't touch me." There are some other fishes that give poisonous wounds as the weever does, and in an American toad-fish (called Thalassophryne) the apparatus is more perfect, for each of the spines has a central canal up which the poison flows. Even with the doctor's help the fisherman's wound is sometimes slow to heal. This may be partly due to the entrance of microbes in early stages, but this would hardly apply to the clean wound that waders sometimes get when they have the bad luck to tread on a weever, which often buries itself in sand in shallow water. There is no doubt that the poison is very powerful.

There are large eels in the Mediterranean and Atlantic called Murænas that are quite different from Common Eels. The Romans used to be very fond of them and kept them in big sea-ponds. Now the Murænas are remarkable because they give a poisonous bite; the venom is produced at the base of several of the teeth,

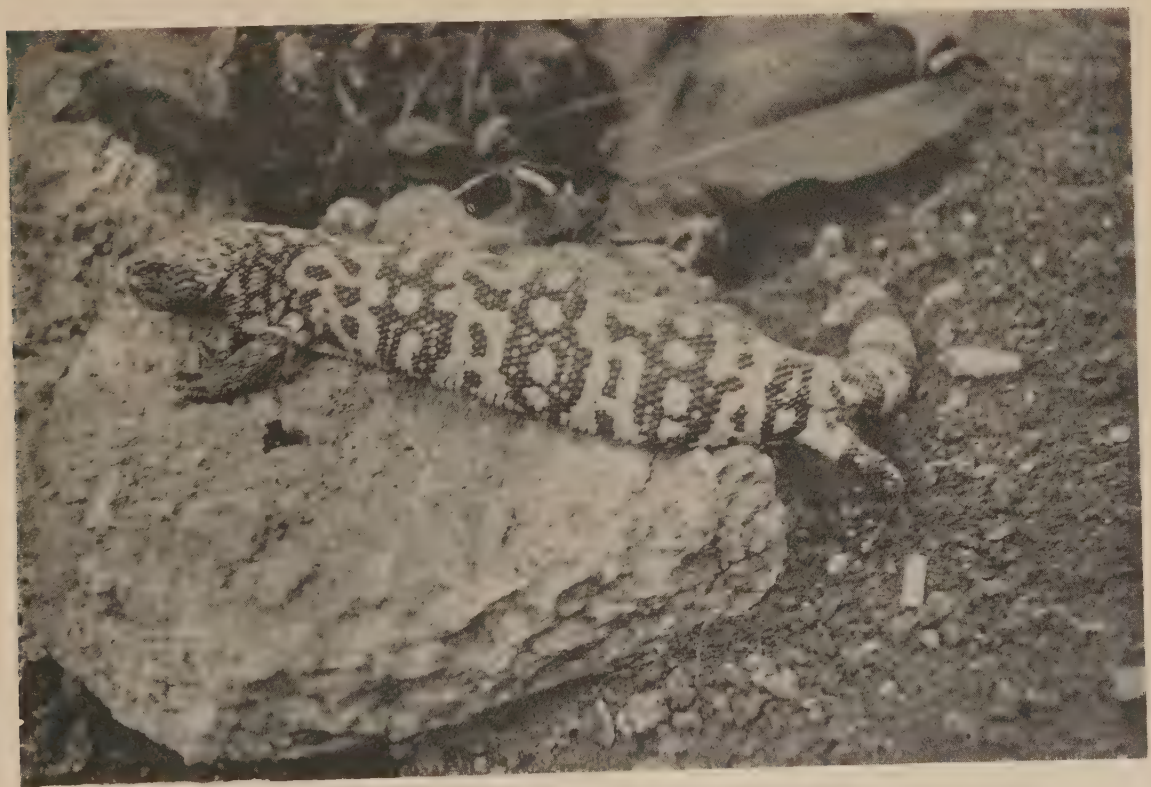


Photo : W. S. Berridge, F.Z.S.

HELODERM OR " GILA MONSTER " (*Heloderma suspectum*).

This is a large lizard, towards two feet long, found in desert places in New Mexico and Arizona. There is another species (*Heloderma horridum*) in Mexico. They are the only poisonous lizards. The poison comes from lip-glands or labial glands, which open near the bases of the teeth of the lower jaw. The Heloderms search for their food in the evenings, and lie quiet during the day. The skin is covered with bony beads.

but there is no special canal or groove. In another group must be placed those fishes that have poisonous flesh, especially at the breeding season. This is true, for instance, of the Barbel, which occurs in some English rivers. The eggs, forming the roe, are more or less poisonous, and so weaken the action of the heart that a man may faint. The poison may pass from the roe to the flesh round about. "To be safe," Mr. Tate Regan says, "it is best to eat barbel only in the late summer and autumn, and to remove the roe as soon as possible after the fish is caught." The strange ball-like Globe-fishes or "Puffers" of warm seas, which are famous for their power of inflating their body, have also poisonous roe and flesh. If an animal has suffered from eating a fish with poisonous flesh, it is likely to leave that fish alone in the future. Thus unpalatability may be as good as armour. Looking backwards, then, we see that fishes may give poisonous wounds by means of spines, or they may give a poisonous bite, or they may be poisonous when eaten.

With few exceptions the amphibians of to-day are naked-skinned. But they make up for the absence of armour by the presence of abundant poison-glands in the skin. The belief that the toad can spit poison dies hard, but the only foundation for it is that the skin is rich in poison glands. From these a creamy irritant fluid oozes out if the inoffensive animal is trampled on or stoned. There is a specially large cluster behind the eye (the parotoid gland), and a little pressure is enough to bring out a number of small drops. If you touch your eye after handling the toad there is likely to be a slight inflammation of the delicate membrane that covers the cornea. The poison is called phrynin, and an injection is rapidly fatal to a small bird or mammal. It acts on the heart and the central nervous system. It seems to be volatile, that is to say, it steals off into the air, for some people suffer from an irritation of the lining of the nostril and severe sneezing after sniffing over a box in which some toads have been carried. Experiments with birds have shown that if the bird has tried a young toad once or twice, it will not touch it again, even if it has had no food for a considerable time.

Photo: F. W. Bond.

HEAD OF A RATTLESNAKE, SHOWING POISON FANGS.

The American rattlesnakes, of which the commonest is *Crotalus horridus*, range from Southern Canada to Northern Argentina. They prey chiefly on small mammals, hunting for them at night. Large rattlesnakes may be four to eight feet long. The photograph shows the bifid tactile tongue, the two large perforated teeth or fangs down which the poison is injected, and a curious sensory pit between the nostril and the eye.

Photo : Neville Kingston.

THE SECRETARY BIRD ANNOYED. A FORMIDABLE ENEMY OF SNAKES.

This remarkable bird (Serpentarius) is represented by two species in Africa. The name Secretary refers to the tuft of long erectile feathers, like quill-pens, hanging over the back of the head. The bird stands about four feet high, the legs being abnormally long. It kills snakes and reptiles by powerful forward kicks, but is also able to strike with its wings. It does not disdain insects and other small creatures.

Poisonousness is a protection, and most Amphibians have it in some degree. The poison of a small tree-frog (*Dendrobates tinctorius*), which ranges from Panama to the Amazons, is used for making arrowheads deadly, and also, in a curious way, for faking the colours of parrots' feathers.

It is remarkable that there should be in the large order of Lizards one case of poisonousness. This is the "Gila Monster" or Heloderma of Mexico and Arizona, a lizard about two feet long, very thick-tailed, covered with a bead-work of bony tubercles. Its colours are dark brown mingled with orange or yellow, and in the tail region there are alternate dark and light rings. Evidently the Gila is not an animal that is readily forgotten, and it does not seem far-fetched to suppose that the livery may impress other animals, and make it easier for them to remember "This strange creature is poisonous." The Gila is sluggish during the day, but crawls about in the evening in search of worms, centipedes, frogs and the eggs of other lizards. The venom is made by lower-lip (labial) glands, which open near the base of the teeth of the lower jaw, and there is no other instance of poison glands being situated in that position. All the teeth are rather fang-like and have a groove in front and behind; but it is only with

Photo : Neville Kingston.

SECRETARY BIRD RESTING. NOTE THE "INSTEP" REGION ON THE GROUND.

The secretary birds are distant relatives of hawks, which have become in great part terrestrial. The feathers go down to the ankle joint; then there is a long, and apparently rather brittle, "instep" region (*tarso-metatarsus*) leading to the partially webbed toes. The young birds remain a long time in the huge stick nest, and are unable to stand upright even when four months old.

Photo : S. Crook.

THE POISONOUS VIPER OR ADDER (*Vipera berus*).

This is the only poisonous snake in Britain. The other two British snakes, the grass snake (*Tropidonotus natrix*) and the rare smooth snake (*Coronella austriaca*) are quite harmless. The adder varies considerably in colour, but is characteristically marked by the zig-zag line of black diamond-shaped marks along the mid-line of the back. It feeds chiefly on small animals like mice, voles, and young frogs.

its lower teeth that the animal can give the venomous bite. It is said to turn on its back before doing so. Men who have been bitten have been known to suffer severely, and a few cases of death have been recorded. The venom is probably of use in killing some of the creatures that the Heloderma eats, such as frogs ; it will also be effective in defence.

What occurs in a single lizard is common among snakes, that glands which are in ordinary cases quite harmless become venomous. This gives us a glimpse of one of Nature's ways of working, if we may so say—making a new thing out of something very old. In snakes the poison-glands are made out of transformed upper-lip glands (labials) or out of a pair of salivary glands, which are known in other animals as parotids. The saliva in ordinary cases contains a ferment which changes starch into sugar ; in certain snakes this is replaced by a poison. This acts on the nervous system in the cobras and their relatives, on the blood-vessels and blood in the rattlesnakes and vipers.

Some animals and birds are able to tackle venomous snakes with great success, being very dexterous in avoiding their bite. The mongoose and the Secretary Bird are two good examples. It seems, however, that some of the creatures that deal with snakes are more than dexterous. They have a mysterious inborn power of resistance—called immunity—so that if they are bitten the venom has no effect. In the same way, if one cobra bites another cobra there is no poisoning, though a *large* artificial injection of a snake's venom is usually fatal to its own species, as well as to other serpents. Snakes cause many a human tragedy, but man is becoming increasingly clever in baulking them. In some cases the bile (a green bitter waste product) in the gall bladder of the snake is a counteractive or antidote to the venom ; and even if man cannot get the bile to swallow when he has been bitten, he can sometimes save his life by swallowing something else that has similar properties. Looking at the matter from a broad Natural History point of view we must remember that snakes—both venomous and innocent—play a very useful part

in checking the multiplication of rats and mice. The snake's fang is a sharp-pointed tooth with a groove on the front side, down which the poison trickles. In many cases the groove becomes a canal opening by a minute hole near the tip of the tooth. This makes it certain that the poison will get into the very deepest part of the wound. In very poisonous snakes, like vipers and cobras, there is a very neat arrangement of bony levers whereby the opening of the mouth raises the fang into a position for striking. At the same time there is a compression of the poison-gland which squeezes some poison forward into the front of the pocket in which the base of the fang is embedded. In some cases the fang is shed periodically; in other cases it may get broken by striking against something hard. Both events are met by the presence of reserve fangs, which are in readiness to replace what has been lost. In mammals there are never more than two sets of teeth; in reptiles there is often an indefinite succession.

What exactly is the use of the venom? It serves as a means of offence and defence; but also to kill the animals used in food. There is a special advantage in suddenly paralysing the victim, for snakes are much given to seizing animals which are too large for the size of their mouth, and the swallowing is apt to be tedious. It would be worse than tedious if the victim were not paralysed before it starts on its journey through the mouth and down the gullet. In strangling snakes, like the boa constrictor, which have no poison, the animal is broken and bruised before the swallowing process begins.

Poisonous Backboneless Animals.

When bathing in the sea people are sometimes badly stung by coming into contact with a large jellyfish. This means that their skin is penetrated by thousands of microscopic lassos, which are poisonous. Each lasso comes from the explosion of a stinging cell, and there are myriads of these in the skin of the jellyfish. Minute as the lasso is, it seems to be turned inside out when the cell that contained it explodes. This brings the poisonous fluid to the outside of the lasso, and it is introduced along with the lasso into the skin. In some cases the fluid has a strange dissolving effect, as may be seen when a fresh-water Hydra stings an insect-larva like the so-called "blood-worm," the young of the harlequin fly. Minute holes are rapidly made right through the firm husk (or cuticle) covering the larva.

To return to the jellyfish, we may notice that in the common violet-blue kind called Aurelia, which is found in all the Seven Seas, the lassos are not strong enough to pierce the human skin; but there is around British coasts a common

Photo: F. W. Bond.

"ALBINO" COBRA (*Naja tripudians*).

The usual colour of a cobra is yellowish to dark brown, with a black and white "spectacle-mark" on the upper surface of the expanded neck region or "hood." The temporary expansion is due to a spreading outwards and forwards of the ribs. But some specimens are pale brown or grey, with a dim "spectacle-mark." The variety photographed here has almost no pigment at all, illustrating what is called "albinism."

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

COMMON SEA URCHIN (*Echinus esculentus*)—A COMBINATION OF ARMOUR AND WEAPONS.

This shows the under surface of the common sea-urchin, which is often about the size of a large orange. In the centre are the five teeth of "Aristotle's lantern," projecting out of the mouth. The shell is covered with regularly arranged sharp spines, moving on ball and socket joints, and helping a little in locomotion. There are five double rows of soft suctorial "tube-feet," used in climbing up a rock. But among the large spines there are many minute snapping spines, like scissors with three blades; and some of these are poisonous. Thus the sea-urchin is well equipped.

big jellyfish (Cyanea), of a bright orange-brown colour, which stings rather severely. The pain is intense and bathers sometimes suffer for days afterwards.

Much worse than a jellyfish, however, is the Portuguese Man-of-War, a strange colony which drifts on the surface of warm seas, buoyed up by a brightly coloured reddish float as big as one's hand, suggesting a large inflated cock's-comb. Divers and sponge-fishers try to avoid touching it, for the stinging causes inflammation and fever. It must be a great protection to the Portuguese Man-of-War to have hundreds of thousands of poisonous lassos; and they are found in all the jellyfishes, swimming-bells, sea-anemones, corals, and zoöphytes.

A little higher in the scale we find poisonous weapons in sea-urchins. Among the ordinary spines, which make the animal like a hedgehog, there are minute spines with three snapping blades on the end of a stalk. At the base of each blade in some of these snapping spines there is a poison-bag, and the poison exudes near the tip. A naturalist called Hornyold once saw a sea-worm troubling a sea-urchin; it was bitten by a number of the snapping blades, from each of which a drop of red fluid oozed out. The worm immediately took cramp and died in a few minutes. The snapping blades that had bitten the worm were broken off at their base, and the dead worm was pushed off. The lost snapping blades would be replaced by and by. Now suppose the worm had recovered from the bites, it is unlikely that it would tackle another sea-urchin, and that is how these defences pay. Some kinds of sea-urchins have a little poison-bag near the tip of their ordinary spines. If the sharp tip enters the skin of man and breaks off, some of the poison gets in, exactly as happens in the sting of a nettle, and the result is a painful wound, often slow to heal.

At a higher level are the stings of bees and wasps, which inject formic acid into the wound. In some cases the consequences of the sting are so severe that one is led to suspect that the entrance of the instrument was accompanied by the introduction of some disease-germs. This is true of the *bites* of some insects. It is not the bite itself that matters, it is the introduction of microbes. It is from the bite of an infected insect that man becomes infected by such terrible diseases as malaria, sleeping sickness, and the plague. For the malaria animal is carried by the mosquito, the sleeping sickness animal by the Tse-tse fly, and the plague-germ

Photo: M. H. Crawford.

STING OF A COMMON WASP (*Vespa germanica*) HIGHLY MAGNIFIED.

An insect's sting is really a transformed egg-laying organ or ovipositor. It is therefore absent from the males or drones. In all probability the sting is derived from a terminal pair of appendages comparable to legs. The photograph shows the posterior part or abdomen of the wasp turned upwards with the sting projecting.

(one of the Bacteria) by the rat-flea. But apart from these terrible cases, it seems that the trivial bite of a contemptible little insect, or the sting of a wasp that brings in a little trace of formic acid, may be followed by unusually severe consequences, the likeliest explanation of which is that some microbe or other gets in.

People often ask whether ants bite or sting. The answer is that all ants bite with their jaws, and that many ants (the workers and queens) can also sting. In most cases the poison of the sting is formic acid (*formica*, the Latin for ant), but in other cases it is something else, not yet analysed. In many ants, however, the sting is either absent or very small. Why should we say that only worker ants and queen-ants sting? The answer is of interest. It appears that a sting is a transformed egg-laying organ (or ovipositor), and is therefore confined to the females, whether true mother-females, like the queens, or females who do not usually produce eggs, like the workers. It is the same with bees and wasps. The males or drones have no sting. The fact that the sting, a venomous weapon, is a transformed egg-laying organ seems extraordinary. It is another instance of one of "Nature's ways," which we shall notice over and over again in this book, that an apparently new thing is often made out of something very old.

The sting of a bee consists of two pointed and barbed needles that play up and down in a hollow guide or "director." This director has a bead for each of the needles to run on, a groove on the needle fitting on to the bead. Each needle has a twisted upper end to which muscles are attached, moving the needle up or down. The needle has also a projecting piece near the top—the piston—which plays inside the cavity of the director. Into that cavity the poison-glands open and the piston forces the poison downwards, so that a good injection follows when the needles are thrust into your skin. This is not the whole truth, but it is true so far as it goes. One of the lessons one soon learns in studying Natural History is that most arrangements are much more

Photo: John J. Ward, F.E.S.

STING OF HONEY BEE, WITH DARTS WITHDRAWN FROM THE SHEATH.

The sting of a bee consists of a gouge-like director in which two sharp needles play. The poison from the poison-glands enters the chamber of the director and is carried forwards into the wound by the movement of the needles or darts.

complicated than they seem at first sight. We noticed how the tip of the spine of certain sea-urchins, piercing our finger and breaking off, may discharge the contents of a little bag of poison. But this is "simplicity itself" compared with the sting of a bee. The poison of the bee seems to consist of formic acid, as in a nettle sting, along with something more deadly, not simply acid.

XXIX
ANIMAL ARMOUR

SOME one has said that there is a great deal of the conjugation of the verb "to eat" in Nature; and that is true. We almost hear some animals saying "We shall eat."

"As I was walking all alane,
I heard twa corbies making a mane,
The t'ane until the t'ither say,
'Whar shall we gang and pick to-day?'"

At another time, the gorged snake, the mosquito shining red with blood, the albatross so full of fish that it cannot rise from the sea, and the sheep chewing the cud, tell us "We have eaten." So far as we know, animals never say "We shall be eaten." But there is no getting away from the fact of *nutritive chains*. What has come to be the routine of Nature is that one kind of animal preys upon another, but that a great many feed on plants. For, of course, they cannot all be eating one another. That would be what is called a "vicious circle."

In the course of time many animals have gained protections against being devoured or even attacked. That does not mean that they took thought for the morrow; it seems to mean that animals are always changing a little from generation to generation, and that changes making for greater safety would be fostered until they became strong and useful and became constant characters of the race. One of the simplest protections is a suit of armour.

§ 1

What a variety of armour! The armadillos have a bony shoulder shield and a bony hip

Photo: F. W. Bond.

SIX-BANDED ARMADILLO (*Euphractus sexcinctus*).

A characteristic South American armadillo, a fine example of invulnerable armour. Between the bony shield over the shoulders and another over the hips, there are six movable bands, which allow of the rolling up. The armadillos are the only mammals with bony plates in their skin. The coarse hairs are well shown projecting between the movable bony plates and also on the under surface.

Photo : W. S. Berridge, F.Z.S.

LITTLE MULE ARMADILLO (*Tatusia hybrida*).

This well-armoured armadillo inhabits the South American pampas. Its name, " mule," probably refers to the long ears. It is a burrower, and can also roll itself up into an unopenable ball. Between the shoulder shield and the hip shield are seen the movable bands of bony plates.

shield, and between these there are girdles of bone which move readily on one another when the animal tucks in its head and tucks in its tail and rolls itself up into an unopenable ball. The armadillos and their relatives are the only mammals that have bone in their skin, and their armour is almost perfection, not only because it is so strong but because it can roll up. The armadillos belong to the same order as the Sloths, but whereas the slow-going Sloths have taken refuge among the branches, the armadillos keep to the ground and trust to their armour and to their power of quick burrowing. They have very strong claws, and some of them disappear very quickly into the earth, sinking straight down, so that the last part of them to be visible is the middle line of their back, covered as we have mentioned with bony plates. This does not give the enemy much to grip at! There is a large armadillo discovered not long ago which, besides being armoured, can run at a good pace and give a vicious bite.

Armadillos.

There is a saying, " You cannot have too much of a good thing," but perhaps there is more wisdom in the Latin motto " Nequid nimis," or " Nothing in excess." For in animal races we sometimes see what looks like carrying a thing too far, as, for instance, in the South American Glyptodons, extinct relatives of the armadillos, which had armour an inch thick, surely much more massive than was necessary. But the same sort of thing is to be seen among men and nations!

Before we leave the armadillo's armour, perhaps we may be excused for making two notes that are a little away from the point. The first is about Charles Darwin, who was greatly interested in the armadillos and their relatives —both living and fossil—which he found in South America when he was on his famous voyage of the *Beagle*. What made him think deeply was this : that South America is very rich in fossils of this order (Edentates), and it is also the headquarters of the living representatives. Now what Darwin said to himself, half in a whisper, was something like this : " It cannot be a coincidence. Surely these numerous

Photo: F. W. Bond.

WHITE-BELLIED PANGOLIN, ARMOURED WITH HORNY SCALES.

These toothless, scaly pangolins have a very long sticky tongue, with which they catch ants and termites. They are not suited for arboreal life, but they have been known to climb to a considerable height after insects. The species photographed has an unusually long tail.

extinct armadillos and ant-eaters and sloths must include the ancestors of those that are now so common in this region." This idea is accepted by all naturalists to-day, but it was Darwin who made it current coin. The other note is very simple, that the people of the country make very effective baskets out of the armadillo's armour. They remove the dead animal, turn the carapace upside down, and sling a handle from the head to the stump of the tail. You could not have a better basket for going to market with. The tendency to develop bone in the skin is very thoroughgoing, for there is a succession of complete bony rings around the tail, each one very suitable for a reliable and decorative napkin-ring.

The Pangolin, a relative of the armadillos, lives in Africa and the Far East, and has very strong scale armour. Very strong horny scales, overlapping like the tiles on a roof, cover the whole of the animal, and are movable one on another. Even when one knows better, it is difficult to look at this strange and very old-fashioned mammal without saying: What a Reptile! And perhaps the scales *are* a legacy from distant reptilian ancestors, for there can be no doubt that mammals sprang from a stock of extinct reptiles. Perhaps, however, it would be nearer the mark to say that mammals have not quite lost the reptile's power of producing scales, for we find scales on the tails of rats and beavers. Among the Oriental Pangolin's scales, and in the young of the African species, there are hairs. We may also mention that there is an interesting dolphin which has scales imbedded in its skin, just as some of the extinct whales had.

There is a certain amount of armour in having a thick skin, and this reaches a maximum in rhinoceros and elephant.

§ 2

Spiny Mammals.

A very effective kind of mammalian armour consists of spines, as we see them in the spiny ant-eater (Echidna) of Australia, the hedgehog, and the porcupine. These animals are almost invulnerable. We say "almost," for, no matter how fine the armour, there is usually an "Achilles' heel." You remember that Achilles was quite safe except in that one spot, by which, as the story goes, he had been held when he was dipped in the safety-giving bath. When we look at the three animals we have mentioned, we notice that they have plenty of hair as well as spines, and this prepares us for the fact that spines are transformed hairs. Another interesting point is this, that the Spiny Ant-eater is one of the two

Photos : F. W. Bond.

THE COMMON HEDGEHOG ON THE MARCH AND ROLLED UP IN A LIVING BALL.

The spines of a hedgehog are transformed hairs, and there are many ordinary hairs besides. There are small muscles moving the hairs and there is a large sheet of muscle that brings about the rolling up. Very occasionally a hedgehog has no spines!

old-fashioned egg-laying mammals (a Monotreme); that the hedgehog is a member of the order of Insectivores; and that the porcupine is a gnawer or Rodent. They belong to three different orders, not nearly related to one another. The transformation of hairs into spines must have occurred three different times, along three different lines.

Birds have no armour, unless indeed we count the horny scales protecting the instep and the toes. Why have birds no armour? Because they do not need it; and because its place is more usefully occupied by feathers. Moreover, heavy armour would be quite inconsistent with flying.

§ 3

Scales and Scutes of Reptiles.

Among reptiles there are many fine examples of armour, for all are scale-covered, and below the scales there are sometimes, as on the crocodile's back, plates or platelets of bone, which are called scutes. A scale is a horny product of the outer skin or epidermis; a scute is a bony plate that develops in the under skin or dermis.

A beautiful and somewhat unusual reptilian armour is seen in the "Gila Monster" or Heloderma, the poisonous Mexican lizard. Its armour consists of closely fitting beads of bone, very like the beadwork that used to be the fashion for table mats. It is rather remarkable that an animal equipped with poison-glands should be so thoroughly armoured, but there may be something in the fact that it is not able to move with the agility characteristic of lizards.

Reminding one of the armadillo's armour is the carapace of the tortoise. Was ever animal better protected? It is boxed in above and closed in below; it can draw in its head and tail and limbs. It lives in a castle. One remembers how the Roman soldiers, attacking a fort, used to link their shields together over their heads, and make what they called a *testudo*, which is the Latin name for the tortoise. They say that only two kinds of enemies can make anything of a tortoise—a strong carnivore and an eagle. The strong carnivore, such as a Jaguar, may get its claws in near the armpit on

Photo: F. W. Bond.

BRAZILIAN TREE PORCUPINE (*Sphingurus prehensilis*).

In adaptation to its arboreal life, this strange porcupine, which is sometimes called Coendoo, has a long prehensile tail. The spines are not so strong or so long as in ground porcupines, and there is abundant shaggy hair.

Photo: John J. Ward, F.E.S.

GREEK TORTOISES (*Testudo græca*).

This tortoise, widespread in the Mediterranean, Balkan, Syrian region, is often imported to Britain as a pet. It is a vegetarian, fond of dandelions and clover. It will learn to eat bread and milk, but never touches "black beetles." It burrows in winter, passing into a state of suspended animation.

each side, and by sheer force "rive" or burst the carapace open. The eagle's method is neater. It lifts the small tortoise in its talons to a great height in the air and then lets it fall on the rocks below. The carapace is shattered and the muscles of the dead tortoise are exposed. The story goes that a Greek Eagle killed the poet Æschylus by mistaking his head for a white rock and letting a tortoise fall on it.

The armature of an ordinary tortoise, like the Greek Tortoise, is rather intricate. In the first place it is covered all over with horny scales belonging to the outer skin (or epidermis). If you look carefully at these scales you will see parallel lines, making a rough quadrilateral figure; the lines indicate the gradual additions to the size of the scale as the tortoise grew older and bigger. They are the ripple-marks of growth. But below the horny scales on the arched back come bony plates, and these are scutes. And below the scutes there are the flattened ribs and the flattened spines of the backbone-bodies or vertebræ. On the under side the flat shield seems to be made, in front, of the flattened collar-bone, and, behind, of flat plates of

Photo: M. H. Crawford.

UNDER SURFACE OF COMMON AMERICAN TERRAPIN.

The name "terrapin" is kept for fresh-water Chelonians, "tortoise" for terrestrial forms, and "turtle" for those that live in the sea. The ventral shield or plastron shows deep grooves, but in true terrapins it is quite immovable. The dorsal carapace is flatter than in a tortoise.

Photo : W. S. Berridge, F.Z.S.

HORNED LIZARD (*Phrynosoma coruntum*).

This spiny lizard, about five inches long, ranges from Illinois through Kansas to Texas and Northern Mexico. It is badly called the "horned toad." It is very inconspicuous on the dry soil. It moves slowly, but snaps up insects with a quick tongue. It basks in the sun by day and buries itself at night.

bone that develop underneath the skin. Perhaps this study is out of place in a book of Natural History, but what we should be clear about is this, that the tortoise's carapace, built on the principle of an arch and very strong, is a puzzling mingling of outside skeleton (scales and scutes) and inside skeleton (ribs and vertebræ). Another way of putting it is that the tortoise has sacrificed a large part of its backbone and all its ribs to making a shield. The only movable parts of the backbone are in the neck and the tail. The crocodilians and many lizards are also well-armoured reptiles, but none has such complicated armour as the tortoise. The combs of "tortoise-shell" are made from the horny scales of a sea-turtle.

Almost all the amphibians of to-day are naked-skinned and trust to their quiet ways and to the unpalatability of their skin. But there is a toad (Ceratophrys) with small scales on its back, and the strange blindworms or Cæcilians, which have taken to an earthworm-like habit, have thin quadrangular platelets imbedded in their skin. These cases take our thoughts back to the extinct giant Amphibians, which had an armour of scales.

§ 4

Among fishes there is plenty of armour, though not so much as there used to be. A fine example is the Bony Pike of North America, which is covered from snout to tail with beautiful quadrangular plates of bone, all varnished over with a glistening silvery enamel (called ganoin). The sturgeon is armoured with five long rows of bony plates, but they do not cover the body, as in the Bony Pike. A single bony scale from the

Armoured Fishes.

Photo : W. S. Berridge, F.Z.S.

MUSKY CAIMAN (*Caiman palpebrosus*) OF GUIANA.

The caimans are nearly related to alligators. They occur in Central America and parts of South America, such as the region of the Upper Amazon. The name "musky" refers to the odour of two glands usually present, in members of the order Crocodilia, near the end of the food-canal and doubtless serving for the recognition of kin by kin.

After the painting by Philip Rickman.

WOODCOCK (*Scolopax rusticula*), SHOWING PROTECTIVE COLOURING.

The nest of the woodcock is a hollow in a sheltered place, made comfortable with withered leaves. It is usually among the withered ferns and herbage of the wood and well hidden. When the bird is brooding, or even resting, it is very inconspicuous, being beautifully camouflaged by the reddish brown, black-marked plumage of the upper surface.

Photo: Neville Kingston.

THE GUIANA DRAGON (*Dracæna guianensis*).

This large lizard, in the family Tejidæ, is found in the Guianas and the basin of the Amazon. It has a remarkable suggestion of the crocodile, as, for instance, in the laterally compressed tail and strong scales. It seems to be a water-animal, probably vegetarian. It may attain a length of four feet.

head of a big sturgeon may be as big as your hand! What a contrast to the transparent "glass-ivory" scales of the herring, which are blown about by the wind around the curing stations. Some of the skates are almost smooth, but the Thornback has hundreds of sharp-pointed scales, particularly strong on the tail, which is sometimes used as a weapon. In these Gristly Fishes, the scales, which are sometimes called "skin-teeth," have an interesting composition. They have a base of bone imbedded in the skin, a core of ivory or dentin, and a sharp tip of enamel—the three hardest tissues in our body, all combined in a Skate's scale!

The Box-fishes of warm seas are strongly armoured with bony scales, which fuse together at their margins, so as to form a firm enclosure. These fishes live a very leisurely life, and perhaps there may be some deep constitutional connection between sluggish movements and heavy armour. Liminess and laziness go together. In any case the armour is useful.

§ 5

When we pass down to Backboneless Animals, we find a diversity of armour even greater than the Backboned Animals show. There are the shells of molluscs—such as the beautiful chambered shell of the Pearly Nautilus, the spiral unchambered shells of the snails, both of land and sea, the unique tusk-like shell of the Elephant's Tooth Shell (Dentalium), the row of eight valves on the back of Chiton, and then all the bivalves, like cockle and mussel, oyster and clam. It must be understood that these shells of molluscs are more than armour; they are houses for their possessors. There are, indeed, molluscs without external shells, such as Cuttlefishes and Slugs, so the shell is not indispensable; but it is a great advantage, not only for protection, but for the fixing on of muscles. There is no life in the mollusc shell; it is made by the skin, and it is added to at the margin as the animal grows; it consists of carbonate of lime on a foundation of organic material called conchin.

Molluscan Armour.

§ 6

Another kind of armour is seen in crabs and lobsters, beetles and scorpions, and many other representatives of the great group of Jointed-

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

SCORPION ABOUT TO STRIKE.

The sting of the scorpion is at the end of the tail, and can be brought towards the head to pierce a victim held in the forceps or pedipalps. But it is not used unless there is real need. If the captive insect is struggling too violently the sting is jerked rapidly forwards and makes an immediately fatal puncture.

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

GIANT WEST INDIAN CENTIPEDE; VERY POISONOUS.

A centipede may sometimes attain the length of a foot. Unlike the cylindrical millipede, it is flattened from above downwards, and has only a pair (not two pairs) of legs on each ring. The millipede is vegetarian and harmless; the centipede is carnivorous and venomous. The poison-glands are situated in the first pair of legs, immediately behind the third pair of mouth-parts.

Photo: M. H. Crawford.

HAWTHORN SAWFLY COCOON ON TWIG.

The cocoon of a common sawfly (*Trichiosoma tibialis*). When the leaves fall off the thorn, the cocoon is exposed, yet not very conspicuously. Moreover, the material is very tough. A lid at the top allows the winged insect to escape.

Footed Animals (or Arthropods). It has a disadvantage compared with the shell of molluscs, that it has to be moulted periodically as long as the animal is growing. The reason for this is that there is no life in it, so it cannot grow; and unlike the mollusc shell, it has no free margin to which additions can be made as the animal grows. A crab inside its shell is like a young knight with a suit of steel armour; as he grows the armour becomes too small for him, just as our clothes become too small for us, and the knight has to get another suit of armour, just as we get a new suit of clothes. So it is with the growing crab or scorpion, or any other Arthropod; it has to throw off its old "shard" every now and then as long as it continues to grow. But, unlike ourselves, it has to make its new suit, and there is a risky time between foisting off the old and making and hardening the new. During that time the crab keeps in hiding—it cannot stand on its legs, nor feed, nor see—and it grows rapidly on the strength of internal stores previously accumulated. Moulting is fatiguing and risky; it is the tax that these animals have to pay for their armour. It may be mentioned that in all the higher insects, which have larval stages, such as caterpillars, all the growing and moulting is completed before the adult winged stage is reached.

A Tax on Armour.

It is not necessary to give any more examples of animal armour, but we must mention cases like caddis-worms, where the creature uses outside things to make a protecting encasement for its body. The caddis-worms that you find creeping about among the stones of the stream or pond, are the young stages of caddis-flies; and they build cases of minute pebbles or fragments of plants, which are glued together by a secretion from the mouth. It is often difficult to draw a firm line between armour and a house, but it is probably better not to apply the word

Photo: Harold Bastin.

A PRICKLY CATERPILLAR.

Too much must not be made of protective structures until their value has been experimentally proved. But it is probable that a soft-bodied creature like a caterpillar is protected to some extent when provided with prickly bristles like those shown here.

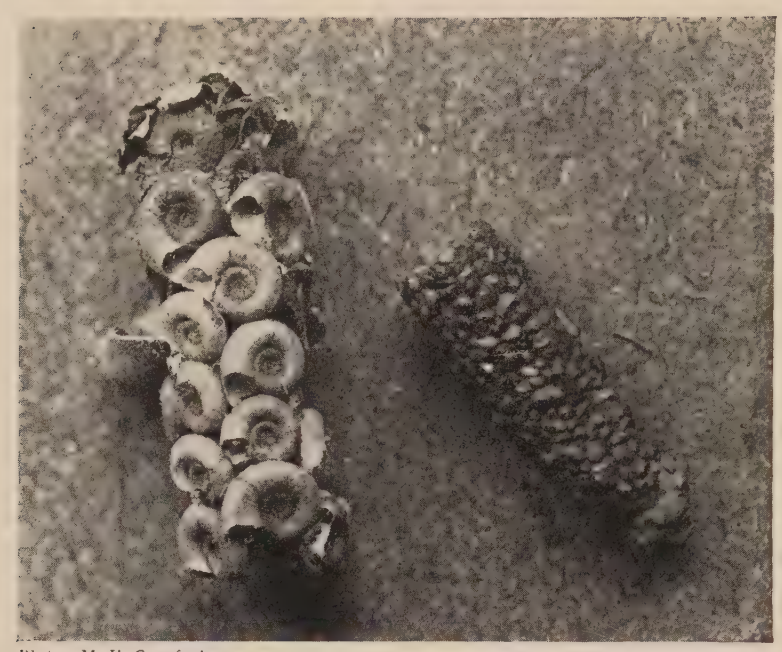


Photo: M. H. Crawford.

LARVÆ OF THE CADDIS-FLY.

Caddis-flies form a family of moth-like insects distantly related to dragon-flies and May-flies. The larvæ are somewhat caterpillar-like, and live in the water. They form protective and concealing cases of all sorts of things. The photograph shows one case made of minute snail-shells, and another made of minute pebbles. The caddis-worms feed mainly on minute plants.

armour to the hard protective cases that are sometimes formed around animals during some quiescent chapter of their life. Thus some insect larvæ surround themselves with hard cases of earth when they pass into the quiescent pupa stage, during which they are changed into flying adults.

The pupa period is a fasting period; it is the time of very drastic internal changes; in most cases there is no active moving about. It is therefore of critical importance that there should be something in the way of a protective case, to keep out injurious influences, to baulk small enemies, and to deceive the hungry eyes of others.

XXX

LIFE-SAVING DEVICES

WE must not think of the life of plants and animals as easy, for they have to struggle against many difficulties. In the not-living world there are strong tendencies to what may be called the running down of the clock: the different kinds of energy tend to become less and less available or usable. They all tend to run down towards uniformly diffused heat. But living creatures are like clocks that wind themselves up almost as fast as they run down, and the general trend of the world is against them. Another way of looking at it is this: that although there are complicated minerals which have resulted from the mixture of diverse ingredients in the melting-pot of the hot earth, the general way of not-living things is to break up into simpler stuffs—to *disintegrate*. Thus a material like clay is the outcome of the breaking down of complicated rocks (felspar-rocks). But living things are on a different tack; they have to break down, of course: but they are always building themselves up again. They are always burning away, but without being consumed. They are like self-stoking and self-repairing engines. Long ago there must have been building up in the history of the not-living world, for corpuscles formed atoms and atoms formed molecules, but nowadays the general tendency is to break down, and we know that it is by giving off atoms that uranium sinks into radium, and radium and thorium into lead. But it is part of the secret of life to rebel against this running down, by also building up. And here we have a deep reason why living cannot be easy.

But we must not go to the opposite extreme and think of living creatures as always hard

pressed and in difficulties. As Walt Whitman said :—" They do not sweat and whine about their condition ; they do not lie awake in the dark." Some of them have a harder life than others, but the big fact is that many of them have conquered the difficulties that beset them, so that they do not need to take any thought for the morrow. Their life is often strenuous, but it is rarely careful and troubled. Most of them enjoy the reward of ages of attention to the motto " Safety first." We have thought about armour, let us think now of some other ways of securing safety.

§ 1

Self-effacement.

There is an old story of a mythical personage called Gyges, who had a magic ring which made him invisible whenever he turned it round. Many animals come very near making themselves invisible. Their general colouring is so like a piece of the surrounding scenery that they are camouflaged. The hare is very inconspicuous on the ploughed field. The curlew on its nest among the bracken and heather, the woodcock sitting among the withered ferns in the wood, the sandy snake or lizard in the desert, the polar bear among the Arctic snows, how well concealed they all are !

An improvement on this general resemblance is seen in those cases where the creature has two or more garbs, which are suited for different times of year. Thus the Variable Hare and the Stoat are brown in summer and white in winter, and the ptarmigan changes its spring and summer suits of ruddy-brown and grey for a winter plumage mostly snow-white.

Better still is the ability to put on the colour that is best suited to the surroundings. In the life of some caterpillars there is a short sensitive period during which the colour of the skin can

Photo : New York Zoological Society.

TREE FROG, INCONSPICUOUS AGAINST A BACKGROUND OF BARK.

Many of the tree-frogs (Hylidæ) are green and best hidden among the leaves. A few are brownish and suited to the bark

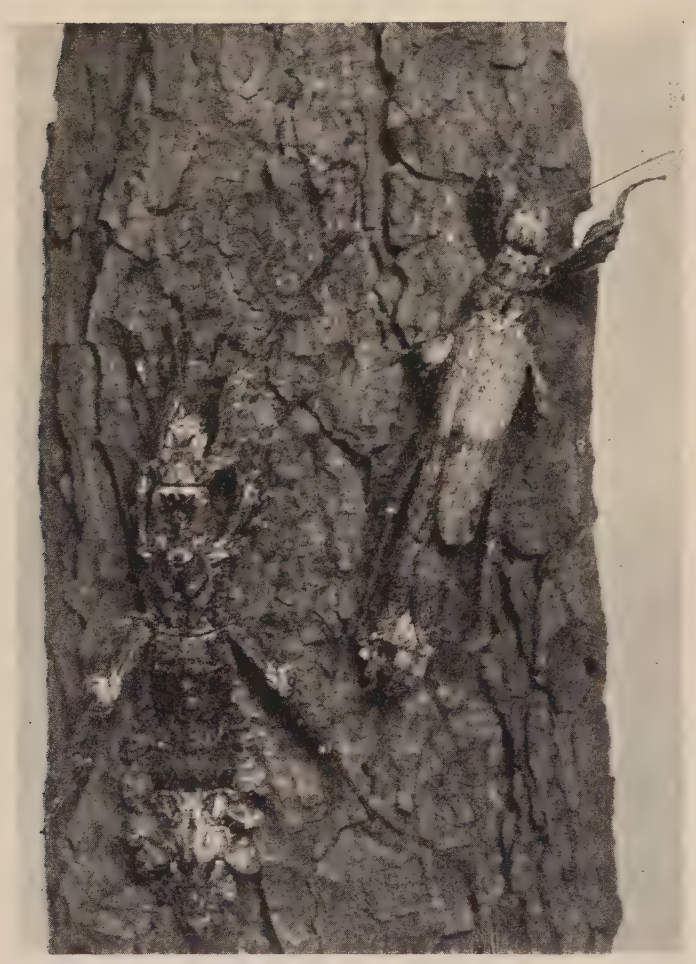


Photo: John J. Ward, F.E.S.

WALKING-STICK INSECTS WHICH RESEMBLE THE BARK OF TREES.

These Australian Phasmids or stick-insects are very conspicuous when isolated, almost challenging attention. But on the rough bark of a tree they seem to fade into invisibility. Not only because of their colouring, but because of their roughnesses they become inconspicuous. The strong probability is that this inconspicuousness serves to protect the insects from the hungry eyes of birds and lizards and other enemies.

change within certain limits, so that the quiescent pupa is very like the surface on which it is fixed. The young of the commonest British Shore-crab (*Carcinus mænas*) show considerable variety of colouring, and it has been observed that in a pool lined with the pinkish calcareous seaweed called Melobesia, the young crabs are mainly reddish, whereas in another pool with abundant sea-lettuce they are mostly greenish, and so on. Some are brown, others grey, others mottled, and they are often almost invisible against their background. It seems that the change is not possible between moults, but only when the new soft shell is hardening.

§ 2

Colour-Change.

Another improvement is seen when the animal can rapidly alter its colour to suit its surroundings, and this is beautifully illustrated by many of the bony Flat-fishes, like plaice and sole. The surrounding colour of the sand and shingle affects the eye (blind fishes do not change colour); the message travels to the brain; it is shunted down the central nervous system and passes by much-branching nerves to the colour-cells of the skin, which grow larger or smaller according to the message that comes to them. This changes the colour of the skin, but the marvel is that the change makes a pattern so like the background. An experimenter once put a flat-fish on a draughtboard pattern, but that was asking too much of the creature! Yet there was an interesting beginning of resemblance. It must be noted that the colour-change is not controlled by the will of the fish;

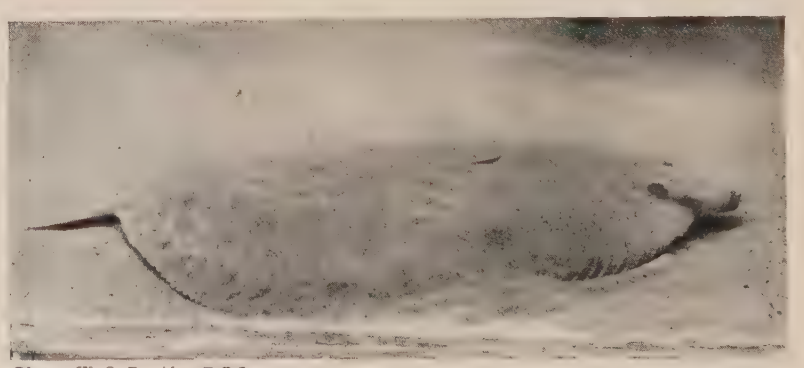


Photo: W. S. Berridge, F.Z.S.

TURBOT ON BED OF SAND.

The turbot (*Psetta maxima*) is one of the larger flat-fishes. It rests on its right-hand side; most of its relatives rest on their left. The down-turned side is silvery; the up-turned side is pigmented, and harmonises with the floor of the sea. The right eye comes to the left side and this extraordinary migration removes the down-turned eye from a useless position where it would also tend to be rubbed.

Photo: John J. Ward, F.E.S.

FOUR WALKING-STICK INSECTS, ABOUT NATURAL SIZE.

The inconspicuousness of these insects among twigs is very striking. In the elongation of the body, the reduction of the wings, the curious angles assumed by the long legs, and the slow movements, they almost attain to invisibility. This probably saves them from hungry eyes.

Photo: John J. Ward, F.E.S.

A PRICKLY STICK-INSECT OF NEW ZEALAND.

One of the many rough-bodied Phasmids which are extremely inconspicuous against rough bark or the like. The variety of form among these stick-insects is very extraordinary.

it comes about in the way similar to that exhibited when we draw back our finger from a hot surface. It is a *reflex*.

In Cuttlefishes, which are molluscs, not fishes, there is a beautiful flushing and blanching due to the contraction and expansion of the pigment-sacs in the skin, and this colour-change sometimes harmonises with the general colour of the surroundings. But it seems to be in the main an expression of the animal's state of nervous excitement at the moment. If so, it is akin to flushing with anger or paling with fear, where the change of colour is due to the expansion or contraction of the small blood-vessels in the skin of our face. And that is due to a chemical messenger (or hormone) which the blood carries from an internal ductless gland (called the supra-renal). And the hermone operates by influencing (vaso-motor) nerve-fibres that go to the blood-vessels. It is worth while pausing over these two chains that we have mentioned—the change of colour in the flat-fish and the change of colour in man's face. Let us write them down opposite one another :—

FISH.	MAN.
	An outside event
	↓
	Excitement in Brain and Mind (an emotion).
Change in Surroundings or Position.	↓
↓	Message down the Nervous System to Supra-renal gland.
Excitement of Eye and Brain.	↓
↓	Increased production of the hormone (adrenalin).
Message down the Nervous System.	↓
↓	Transport by the blood
Contraction or Expansion of Colour-cells in the Skin.	↓
	Contraction or Expansion of Blood-vessels under influence of nerve-fibres

Another improvement in self-effacement is seen when the *shape* of the animal or part of the animal is like something quite different. Many insects are like leaves ; others like branching twigs ; others like prickles or seed-boxes. The perfection of the concealment requires to be seen to be believed, but of course it is necessary

Photo: M. H. Crawford.

CATERPILLAR OF SWALLOW-TAILED MOTH (*Ourapteryx sambucaria*). PROTECTIVE RESEMBLANCE TO A LEAF-STALK OR PIECE OF STEM.

This caterpillar is brownish, variegated with reddish or purplish. It is common among ivy, feeding on the leaves, and is quaintly twig-like. It is a retiring creature in any case.

Specially drawn for this work by Roland Green, F.Z.S

COMMON WRENS

Wrens are among the most attractive of birds, alert in movement, joyous and full-voiced in song, overflowing with energy and good spirits, incessantly industrious. The males sometimes sing as they fight, and they build extra "cock-nests" as if they enjoyed the art.

to collect evidence to prove that a resemblance which deceives our eyes does really save the creature from the eyes of its particular enemies. Our eyes are seldom *hungry*.

Some spiders are like little patches of lichen; others are like knobs on a branch; and there is one in Malaya which has an extraordinary resemblance to a bird-dropping on a leaf.

§ 3

Mimicry.

Perhaps the most perfect example of the leaf-insects is the Praying Mantis (*Mantis religiosa*) already fully described under the heading of carnivores. Its wings are leaf-like, and its legs are flattened out like leaflets. It occurs in two varieties, green and brown, and it moves slowly about among the leaves of shrubs and tall herbage, well-concealed by its leaf-likeness. It has a strange way of raising the front part of the body and folding its first pair of legs as if in a devotional attitude.

§ 4

When an insect is like a leaf we use the term protective resemblance. For it is useful to keep the word mimicry for something more subtle. There are unpalatable butterflies which birds seldom touch. Perhaps an inexperienced bird will snap one up, but it does not make the mistake often. It has been proved by experiment that birds remember mistakes of this sort and leave unpalatable creatures alone. But it sometimes happens that the unpalatable butterflies have palatable "doubles," not nearly related to them, but living in the same area, and always in a minority. It seems almost certain that these palatable "doubles" are much safer in the battle of life because of their close resemblance to their unpalatable neighbours. The "mimickers" are left alone because birds have learned not to waste time on the unpalatable "mimicked"; and the resemblance between the two is often very close, though there is no near relationship.

Photo: John J. Ward, F.E.S.

PROTECTIVE RESEMBLANCE OF LAPPET MOTH.

This moth (*Gastropacha quercifolia*) has reddish-brown wings, and when these are closed it presents a striking resemblance to a withered and shrivelled leaf. The resemblance is increased by the toothed margin of the wings, like that of many leaves. The photograph shows a moth with its wings spread, and directly below there is another with its wings folded. The invisibility in this case is startling!

When we use the word "mimicry" we must not fancy for a moment that there is any conscious imitation or putting on of disguise. The resemblance has come about involuntarily by the sifting of novelties or variations. New departures are common among butterflies and moths, and changes of the palatable in the direction of the unpalatable would be decidedly

Photo: Roland Green, F.Z.S.

MIMICRY IN BUTTERFLIES.

The topmost butterfly is *Anosia plexippus* from the vicinity of Chicago, and may be called the "model," as it is believed to be unpalatable. The second butterfly, *Limenitis archippus*, is a "mimic" from the same region; it is not a near relative of Anosia, but is obviously very like it. The third butterfly is another species, *Limenitis artemis*, from Manitoba, and shows no mimicry. But it may indicate the type from which *L. archippus* has diverged.

advantageous and more likely to be successful than changes in another direction or no change at all. Moreover the mimicked and the mimickers are, after all, both butterflies, and probably had a common ancestor long ago.

There is another kind of mimicry even more puzzling, where the mimickers are unpalatable as well as the mimicked. The theory is that the unpalatable mimickers are saved from attack by being like the unpalatable mimicked, which are in the majority. The shield of the majority is, as it were, over the minority.

§ 5

Warning Colours.

Sometimes animals seem actually to advertise themselves, so conspicuous are their colours; and the theory here is that they are safe in being unpalatable or noxious, and that their flaunting garb serves to impress their enemies with the fact. Some of the poisonous snakes are also very conspicuous. They can afford to be, one may say, but perhaps there is more than that; perhaps the conspicuous colours linger in the memories of meddlesome animals, and keep them from making foolish experiments on the snakes. If so, the snakes will be saved from wasting their venom.

The salamander, again, one of the Amphibians, has a conspicuous livery of bright yellow and black; but the salamander has a poisonous skin and should be left alone. Some very unpalatable insects, like the scarlet and green Burnet Moth, are very conspicuous, and the same is true of some noxious caterpillars. There are so many of these cases that one feels there must be good sense in the theory of "Warning Colours."

§ 6

Masking.

On a different line altogether are those animals that put on disguise, for there is a smack of deliberateness in what they do. The common Sand Crab (*Hyas araneus*) often carries about a little garden on the top of its shell, so that it looks like a piece of the scenery of the shore-pool, and not like a crab at all. *This is masking.* The garden on the crab's back consists mainly of seaweeds, but sometimes there are pieces of sponge and

Photo: M. H. Crawford.

THE SPOTTED SALAMANDER (*Salamandra maculosa*).

This common continental salamander, a relative of the newt, has a variable colouring of yellow and black in different proportions, and is often a conspicuous animal. But it can afford to be so, for its glandular skin exudes an unpalatable and repellent secretion.

zoöphyte. More than one naturalist has seen the Sand-Crab or some other grasping a piece of red seaweed in its forceps, holding it to its mouth, nibbling at it for a little, and then rubbing it on the back of the shell so that it entangles on some of the bristles. Seaweeds absorb all their food (sea-water and the carbonic acid gas mixed in it) by their fronds, and their so-called " roots " are simply anchors ; so they can flourish on the back of the crab just as well as on a rock. The result is that the crab is disguised, somewhat after the fashion of " the walking-wood of Birnam," when the soldiers hid their approach among the copses by cutting down branches of the trees and holding them above their heads. On the sea-shore the crabs and hermit-crabs must have something corresponding to a bad reputation, for they are pugnacious and voracious animals, so we can understand the advantage, in attack especially, in looking like an innocent tuft of seaweed.

There is sometimes a remarkable deliberateness in the crab's behaviour. Thus there is one kind that cuts the firm tunic off a sea-squirt, and, after trimming it to shape, puts it over its own shoulders.

§ 7

If you lift a good many periwinkle and dog-whelk shells from the floor of a shore-pool and put them in a soup-plate with sea-water, you are likely to have three things before you. There are living molluscs which have drawn into their shells. If you watch you will soon see the head protruded and its horns, and

Photo: John Armitage.

SIX-SPOTTED BURNET MOTH AND COCOON.

This species of Burnet Moth (*Zygæna filipendulæ*) has greenish wings with spots of bright red, and is therefore very conspicuous. It is safe, however, because of its unpalatability, and seems to have few enemies. Its greenish cocoon is often seen attached to grass stems.

the flat surface, called the "foot," on which the animal glides along. Secondly, there will be dead and empty shells. But, thirdly, as you watch you will see hermit-crabs showing themselves out of some of the shells, extending their beautiful feelers, their forceps, and walking-legs. They soon betray themselves by their quick movements, and if you lift one when it is on the prowl you will see it jerk itself into its shelter with a click. It is like a jack-in-the-box working the wrong way round.

The Hermit-Crab Again.

It is plain that the hermit-crab masks its real nature by borrowing the shell of a mollusc. But there is often an improvement on this, for there may be a sponge growing right over the borrowed shell, and in one well-known case (*Suberites domuncula*) the sponge has a strong repellent odour and is crammed with sharp flinty needles.

On British shores the borrowed shell of a hermit-crab is sometimes covered by a thick growth of a pinkish zoöphyte (Hydractinia), and in some other countries the masking growth is prickly all over, like the fruit of a Spanish chestnut. In these cases it seems that the zoöphyte simply settles on the shell and spreads, whereas in the crabs we started with there was active bedding-out of seaweed.

There is one drawback to the hermit's masking. When it has grown too big for the house it has leased, and has to flit to another—a change that it effects very quickly—it has to leave its camouflage behind, and begin afresh.

§ 8

There are many animals like frogs which will not eat anything that is not living. It is therefore in many cases an advantage if an animal can remain perfectly still, and in a general way it may be said that an animal in danger is most likely to be detected when it moves. Not unnaturally, therefore, there are many animals that "feign death."

Feigning Death.

But there are different levels in the feigning. Sometimes it is nearer faint than feint; sometimes it is a trick and sometimes a reflex. On the highest level is the playing 'possum of various mammals, such as the fox, which *shams* death. On a lower level is the fear-paralysis, which seizes some of the higher animals, e.g., a rabbit about to be overtaken by a stoat. Then there is the habitual instinct of lying low, which many animals exhibit when they are suddenly touched. Thus, if you lift a click-beetle from the ground it lies motionless on your hand, obeying an inborn instinct which may often save its life. One dare not credit it with intelligence! All of a sudden it violently contracts certain muscles and is gone. But somewhat different we think is the rigidity which comes over some animals in unusual circumstances, as when we seize an Edible Crab between our finger and thumb and swing it several times backwards and forwards in the air. It falls into a strange state called *animal hypnosis*, and a closely similar condition often sets in when a simple animal gets a sudden shock, as

SPIDER-CRAB MASKED WITH SEAWEEDS.

Species of Stenorhynchus and Hyas are often seen in the shore-pools very thoroughly disguised with a growth of Algæ and zoöphytes; and in some cases the crab has been seen rubbing the seaweed on its shell so that it becomes fixed among the bristles.

Photo: John J. Ward, F.E.S.

BRITISH BUFF-TIP MOTHS (*Phalera bucephala*) WHICH RESEMBLE BITS OF BROKEN BRANCH.

This moth flies about in June and July, but is rarely seen in the daytime. When it settles down, it folds its wings very close to the body, and it has then a strong resemblance to a piece of stick.

when it suddenly passes from darkness to brilliant light.

§ 9

A Limb for a Life.

One of the strangest ways in which animals get out of a tight place is by surrendering a part and thus saving the whole. We may speak of it as giving up a limb for a life. It is not to be mixed up with cases where a fox or a stoat cuts itself free from a trap by actually biting off its foot, for this is done very deliberately, whereas the starfish's surrender of an arm, or the crab's surrender of a limb, or the lizard's surrender of a tail is on a different line, which we illustrate when we draw back our finger from a very hot plate. It is what is called a reflex action, and does not require any will.

When a starfish is seized by one of its arms, or when a dislodged stone pins down one of its arms, it surrenders this arm and escapes with the other four. What it has lost it can in the course of time re-grow. The starfish has no brains, not even what are called nerve centres, so we dare not use any big word in speaking of its behaviour. If we say that it has *learned* that it is better that one member should perish than that the whole life should be lost, we must hasten to add, "But this learning is not like our intelligent learning; it is at a much lower level." Yet it serves the starfish well.

A not uncommon accident among the rock-pools is that a stone dislodged by a breaker

Photo: John J. Ward, F.E.S.

BRITISH BUFF-TIP MOTH, WITH WINGS OPEN AND WINGS CLOSED.

This moth has violet-grey fore-wings flecked with brown and grey. The whitish eggs are laid in clumps on the under side of leaves. The yellowish caterpillars feed in companies on trees and bushes of many kinds and soon do much damage to the foliage. The chrysalis is purplish-brown.

Photo : F. W. Bond.

AUSTRALIAN FROG-MOUTH OR PODARGUS AT REST.

This quaint bird, a distant relative of the nightjar, has plumage that harmonises well with the bark on dead tree-stumps. It sleeps during the day in the upright position shown in the photograph, and the protective resemblance makes it almost invisible.

slides down on a crab and badly bruises its leg. Or the leg may get badly hurt in a fight. When this happens, the crab breaks off the whole limb across a weak line near the base, the breakage being due to the violent contraction of muscles that work against one another at this spot. If that were all, there would be a risk of the crab bleeding to death, but there are two bandaging flaps inside the leg at the breaking plane, and when the bruised leg is set adrift the wound is at once closed up. This is very neat work, reminding us of the way in which a corky partition grows across the place where a leaf is fastened to the twig ; for this corky partition not only helps the fall of the leaf, it forms a scar over the wound. Underneath the crab's bandage a new leg is formed in miniature, and at the next moult this is jerked out like a jack-in-the-box. It is a curious, flabby, dwarfish leg, but it soon hardens and is at any rate better than nothing. In different crabs the breakage occurs in different ways ; thus in the shore-crab and the edible crab the leg cannot be got rid of unless the part towards the tip can be pressed against something hard, such as a stone or the animal's own shell. But in the sand-crab and the swimming-crab this is not necessary. It is interesting to find that an injured hermit-crab removed from its shell pulls or even bites at its broken leg, while if it is left to itself it can jerk it off as quickly as it clicks back into its borrowed shell.

Some lanky spiders and some insects like grasshoppers part with their legs on very slight provocation, and there is no bleeding. The same is seen in rather interesting animals called harvestmen, which are distantly related to spiders. We often see them moving quickly about among the stubble of the harvest-field, with extraordinary long legs, over twenty times the length of the body. The harvestmen hunt in the evening or at night for small insects whose bodies they suck, and they are said to drink drops of dew. If we catch one of them by the leg it at once gives it up to us and hurries away as if it were moving on stilts.

It is difficult to understand this surrender of a considerable part of the body in many animals ; and it should be noticed that the surrender may serve some purpose quite different from life-saving. Thus many male cuttlefishes give away a whole arm at the pairing season. It becomes swollen and laden with packets of male elements or sperms ; it becomes weak at the base and is

shaken off as a whole into the mantle-cavity of the female. As it has some power of muscular wriggling, even after it is set free, the old naturalists mistook it for a worm, and called it Hectocotylus, which was rather a bad mistake !

Another strange case is that of the male and female Termites or white ants, which use their wings only once in a lifetime, in what is called the " nuptial flight." When they settle down again they jerk off their two pairs of wings across a weak line at the base, and only the stumps are left. This presence of a line of breakage is very interesting, as the same thing is seen in other animals very widely apart, such as crabs and slow-worms. But in the last-named, as in most other lizards, there are numerous lines of weakness where breakage may occur. Many of the tail vertebræ are divided into two by a soft plate or septum of gristle, and it is across one of these septa that the breakage occurs. From the breaking-plane a new make-shift tail is developed if the lizard escapes.

Photo : M. H. Crawford.

STARFISH RE-GROWING AN ARM.

When the arm of a starfish is pinned down by a dislodged stone or gripped by some enemy, such as one of the carnivorous sea-slugs, the animal over-contracts the muscles at the base of the arm and surrenders it. If the starfish escapes, it can gradually grow a new arm in place of the one that has been surrendered.

Photo : John J. Ward, F.E.S.

HARVESTMAN AMONG GRASS.

The remarkable animals called " Harvestmen " (Phalangium) are distant relatives of spiders, with extremely long legs, which readily break off in critical situations. Also of protective value is the habit of emitting an odorous fluid from near the base of the first pair of legs. The harvestmen move about quickly among the stubble or herbage, hunting for larval insects, young spiders, and the like, and drinking from the drops of dew.

Under flat stones on the shore there are sometimes long ribbon-worms or Nemerteans like coiled pieces of elastic band. Some of them are several feet in length, and we have measured a specimen of *Lineus marinus* over twelve feet, which is, however, far from being a record. These elastic worms show great capacity for self-mutilation or autotomy. On the slightest provocation, or none that can be discovered, they will divide into many pieces, and a single piece can re-grow a whole. This kind of breaking power is probably the simplest expression of what is seen elaborated and perfected in the crabs and lizards, starfishes, and harvestmen. It seems likely that lanky growth involves lines of weakness, unless there are special arrangements working in the opposite direction. Thus a chamæleon's tail, being specially adapted as a prehensile structure for coiling round a branch, does not break off with the readiness

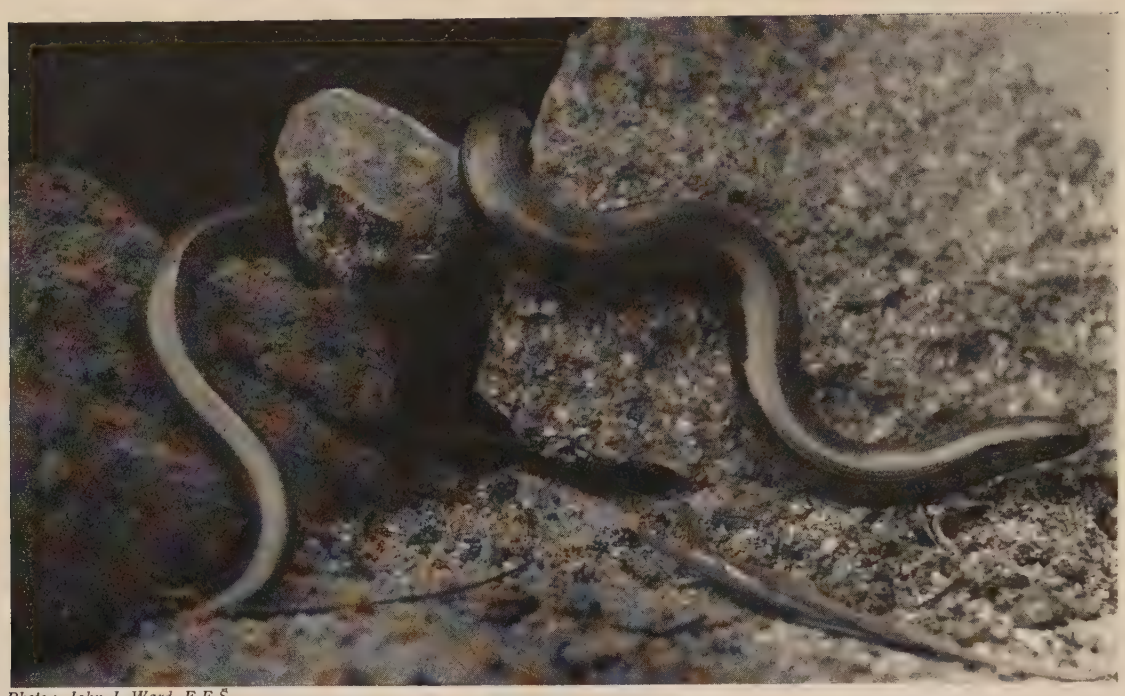


Photo: John J. Ward, F.E.S.

THE SLOW-WORM (*Anguis fragilis*), THAT CAN SURRENDER ITS TAIL TO SAVE ITS LIFE.

This limbless lizard, not uncommon in some parts of Britain, attains a length of about a foot, of which more than half belongs to the tail. When it is threatened with capture it over-contracts its muscles and the tail readily breaks off, right through the middle of a vertebra. Thus the animal escapes and the lost tail can be replaced by a fresh growth or "regeneration."

that is seen in most other lizards; and if it is broken off by force it is not re-grown. An elephant's trunk is long enough, but it is such a finely unified structure, so intensely alive throughout, that there is no risk of breakage! But given lines of weakness in simpler structures, lines where vitality wanes, we can understand how this might actually become a source of strength. As we have seen, it may save the creature's life, it may make the repair of wounds easier, it may be a method of vegetative multiplication, and it may have other uses still.

XXXI

DEFENCES OF PLANTS

ONE of the big facts that stand out when we study the world of living creatures is the circulation of matter. The chemical and physical building materials of one organism are soon used in the construction of another. The gull swallows the fish which devoured the crustaceans which fed daintily on microscopic diatoms in the sea. There is a continuous cycle of reincarnations or new embodiments of the old. But in the long run we must always come back to green plants, for they alone, with the help of the sunlight, are able to feed on the purely inorganic. The ordinary green plant feeds on air and soil-water, which it builds up into sugars and proteins and other complex carbon-compounds. On these in turn the animal kingdom depends, for although there are thousands of carnivores, insectivores, and omnivores, we must in the long run come down to herbivores, which depend on plants for food.

When we think of all the grazing herds, all the fruit-eating and seed-eating birds, all the

leaf-eating insects, all the root-eating grubs, and so on, the reasonable question arises: How do plants hold their own? Animals like the field voles and the locusts often turn a green and pleasant land into a frowning desert. Why does this not happen oftener? How is it that the animals do not devour all the plants and thus sign their own death-warrant? The main answer is that most plants can multiply so abundantly that they can stand a great deal of thinning. Moreover, when vegetarian animals approach the end of their tether, having eaten up the bulk of the available plants, their numbers are automatically reduced. The legions of rodents have their ranks thinned by starvation. Again, one kind of animal acts as a check on another; the birds keep down the insects. The weather also is often on the side of the plants, and it is to be remembered that few animals eat the whole plant. Even when the fruit is eaten, the seeds may still be scattered.

How do Plants Hold Their Own?

While the survival of plants mainly depends on their abundant multiplication and on their almost inexhaustible food-supplies in air and soil-water, it must be recognised that they are not without their defences. When the Venus Fly-Trap on the swamps of Carolina shuts its very animal-like mouth on an insect, when the Sundew on our moors bends its very animal-like tentacles around the entangled midge, we have an illustration of a plant on the offensive, but this is exceedingly rare. There is also an instance of plants on the offensive when virulent bacteria bring thousands of men to the dust, as in the plague, or thousands of animals, as in some forms of cattle disease. But microbic plagues are very rare among animals in Wild Nature. It must be admitted, then, that plants seldom make a thrust. Let us consider some of their defences.

Plants on the Defensive.

A briar bush is covered with somewhat triangular prickles which break off very neatly when they are pressed sideways. This shows that they are very superficial structures—skin structures. Botanically considered, a prickle is a hardened hair.

Thorns and Spines.

A spine, on the other hand, is a hardened leaf,

Photo: E. Step, F.L.S

PRICKLES OF DOG ROSE (*Rosa Canina*).

Prickles are skin-structures, comparable to hardened hairs. When pressed to one side they break off neatly, showing their superficial nature.

Photo: M. H. Crawford.

LEAF-SPINES OF HOLLY (*Ilex aquifolium*).
The spines are due to the hardening and dying away of points at the end of leaf-veins, and they disappear in well-nourished upper leaves.

soil and plenty of sun and wind—to pull the trigger. Similarly with hollies, the more luxurious the conditions, e.g., plenty of moisture and shade, the less spinose are the leaves. Spininess is a constitutional peculiarity of certain plants, which crops out when the conditions of life are unfavourable. It means a reduction of soft parts, an increase of hard tissue, and an ebbing vitality.

The reduction of soft leaf or shoot tissue may economise the loss of water in arid places, where many sharp-spined plants like cactuses and prickly pears flourish, but it is also probable that the sharpness does in some cases prevent the plant from being devoured. One must be careful, however, for it is instructive to watch a goat nibbling off leaf after leaf from a thorny plant, without once scratching its nose. And everyone knows that donkeys enjoy thistles.

The sharp structures sometimes as in the barberry, or part of a leaf, as in the holly. In some acacias the spine is a stipule—the name given to a small structure that often occurs at the base of the leaf-stalk, very familiar as two projecting wings at the foot of the leaf-stalk in the rose.

In the third place, a thorn is a reduced and hardened shoot, as in the hawthorn, and it may betray its botanical nature by bearing a leaf or two, for only a shoot could bear a leaf. On bushes of furze, gorse or whins there are two kinds of sharp things—reduced and hardened leaves (spines), and reduced and hardened shoots (thorns).

Now experiments with whins have shown that if the young plants are grown in damp atmosphere and in the shade, there is very little in the way of spines. The ability to produce spines is part of the inherited constitution of the whin, but it requires certain conditions—dry

Photo: M. H. Crawford.

STRANGE THORNS OF THE "CHRIST THORN" (*Ziziphus spina-christi*).
In this plant the spines occur in pairs, one straight and the other recurved; they are transformed stipules, at the base of the leaf.

Photo : H. J. Shepstone.

BIRREI, CACTUS, ADAPTED FOR LIFE IN DRY REGIONS.

In cactuses the leaves are often absent, and this reduces the loss of water in transpiration. The leaves may be represented by the numerous spines, but some botanists regard the spines as superficial structures, more like prickles than leaves. They may be protective against browsing mammals.

Photo: E. Step, F.L.S.

FURZE, WHINS OR GORSE (*Ulex europæus*).

This familiar plant, which has almost always some flowers in bloom, lives mostly in dry places, such as heaths, and its foliage is much reduced. The leaves are turned into flat green spines; and there is a second kind of spine, thicker, stouter, and branched, which is really a transformed green shoot. All this spininess is an adaptation to scarcity of water, for transpiration is reduced; but there may also be some protective value in the spines. The young plants have soft leaves with three leaflets.

occur in strange places, where their presence may confer some special protection to their bearers. Thus there are spines on the underside of the huge floating leaves of the great Victoria Regia water-lily, which look as if they were meant to ward off the attacks of aquatic animals. And what shall we say of the thorns guarding the entrance to the pitcher of at least one of the Pitcher-Plants (Nepenthes), which look as if they were meant to baulk an insectivorous bird? Then there are the hollow thorns of some Acacia trees which shelter a bodyguard of friendly ants, sometimes useful in driving off the leaf-cutters.

Our general conclusion is that the production of sharp structures is a constitutional peculiarity. While it means ebbing vitality in hair, or leaf, or shoot, in some cases it may prove a very useful defence.

Crystals.

In a shady wood one sometimes finds the Cuckoo-Pint (*Arum maculatum*), one of the strangest plants in Britain. If you take a minute piece of the glossy green leaf and nibble it, you soon experience a painful irritation in the lips and tongue. This is due not to any poison, but to the presence of immense numbers of sharp crystals of oxalate of lime, which pierce the lining membrane of our mouth. The crystals are by-products in the chemical manufactory of the leaf; that is their first meaning; but it seems that they have a second meaning in protecting the Arum from the attacks of snails and slugs. It has been shown that if the crystals are dissolved away with hydrochloric acid and the leaves well washed, the snails will eat them. There are many similar cases where plants are defended from snails and caterpillars and other enemies by the presence of crystals, which form what might be called an internal armour. It must be allowed that some leaves and shoots are much more difficult to injure than others, and that the hard envelopes of some seeds save them from injury in the

food-canal of the bird or beast that has eaten the fruit.

Other Mechanical Defences.

In warm countries it is sometimes the custom to put the foot of the table leg into a tiny jar of paraffin, for this traps the white ants which come out of the floor and would tunnel in the wood. So the cisterns formed where the leaf-bases of the teasel embrace the stem, serve as moats which baulk the ascent of unwelcome insect-visitors. There is often a little entomological collection in these cisterns.

In many places one sees a girdle of tarry canvas fastened round the stem of a tree to stop the ascent of injurious insects, such as caterpillars. The same sort of defence is seen on the stems of many wild plants, such as some of the campions and Lychnises, for there are glutinous rings which act as deterrent moats. It is interesting to find that the indomitable ants sometimes make bridges over these moats, and even over man's tarry girdles. If they are in a hurry they make a living ant-bridge, which soon becomes a dead one. Professor Neger mentions a curious fact in connection with plant-defence, that grazing animals in Samoa, for instance, will not eat the very abundant Sensitive Plant. It collapses when touched, and the suggestion is that the herbivore thinks it uncanny.

The Stinging Nettle.

There is no better example of a stinging plant than the common nettle. The stings are transformed hairs, raised on short skin-pillars. At the lower end of the hair there is a bulb containing irritant fluid, which seems to consist in part at least of formic acid. The tapering upper end of the hair is stiff with flint; the delicate point, closed by a little knot, is brittle with lime. When we touch the leaf lightly the point breaks off and the stiff, hard needle enters our skin, introducing a droplet of the irritant fluid from the basal bulb. When we grasp the nettle firmly we press the hairs down parallel to the surface of the leaf, and the stiff needles do not enter our skin. In

Photo: John J. Ward, F.E.S.

BUTCHER'S BROOM (*Ruscus aculeatus*).

The flattened, leaf-like branches (Phylloclades) ending in sharp points, arise from the axils of minute scaly leaves. About half-way up the flattened branch there is another scaly leaf, in the axil of which there is, as the photograph shows, a small greenish-yellow flower, or a berry-like fruit. The sharp points are doubtless protective.

Photo: E. Step, F.L.S.

THE CUCKOO-PINT OR LORDS AND LADIES (*Arum maculatum*).

This interesting British plant has a curious inflorescence sheltered in a greenish-yellow bract or spathe, and showing small male and female flowers at the base of the axis or spadix, which is reddish at the top and has a fetid smell. Flies enter the spathe, get entangled, and are kept prisoners until there is a discharge of the pollen, which they proceed to carry to the next cuckoo-pint they visit. The fruits are conspicuous reddish berries.

some persons the process of " holding the breath " seems to alter the skin for a moment in such a way that the points of the stinging hairs do not catch even on a light touch.

There are other irritant hairs besides those of the nettle. Thus most people are well advised to use gloves when working with the Chinese Primrose (*Primula obconica*), so common in greenhouses.

Everyone has heard of the fabled Upas Tree that exerted a fatal influence on people who came within its spell. Its scientific counterpart is the so-called Poison Ivy or Poison Vine, a plant a little like a Virginia Creeper, which has an often dangerous influence on susceptible people. It is not even necessary that they should touch the plant, for the poison, which is resident in a milky juice, appears to be carried through the air on floating particles. One might almost regard the Poison Ivy as aggressive.

Chemical Defences.

The poisons of plants are mostly waste products or by-products of the chemical processes that go on as part of the everyday vital routine (metabolism), but they may have a protective value, checking the appetite of animals. There are irritant acids like formic acid, bitter stuffs like tannin, ethereal oils like eucalyptus and turpentine, and strong alkaloid poisons like those of hemlock and Deadly Nightshade. It must be noticed, however, that what is one animal's poison may be another animal's food. Many caterpillars enjoy a meal of very poisonous plants and are none the worse. Strychnine,

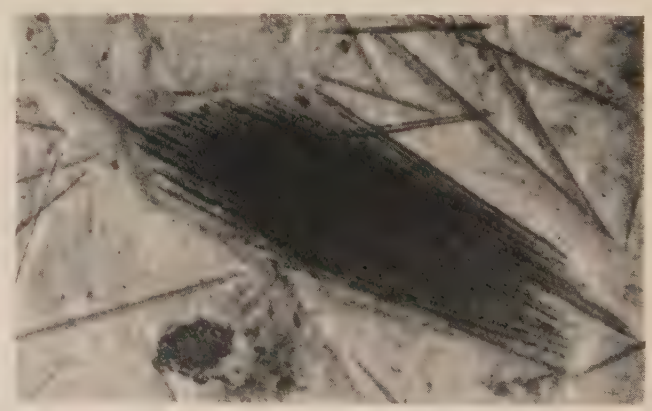


Photo: John J. Ward, F.E.S.

HIGHLY MAGNIFIED CRYSTALS OF CALCIUM OXALATE FROM THE LEAF OF THE CUCKOO-PINT.

These microscopic needles are very abundant, and if a snail nibbles a part of the leaf they penetrate the lips and doubtless produce smarting and irritation as in our own lips. They doubtless serve as deterrents, saving the leaves from snails, but they are primarily by-products in the chemical routine of the leaf.

Photo: John J. Ward, F.E.S.

PART OF THE STEM OF A NETTLE,

showing the numerous stinging hairs, much magnified. They probably protect the plant from browsing animals.

which is a poison to man except in small quantities, does no harm to many a bird. But we have said enough to show that plants are not without their defences in the battle of life.

But we cannot pass from the subject without two cautions. The first is that however well a plant may be protected, some animal or other will get the better of it. What could be more repellent than a cactus or Prickly Pear with its bristling needles, yet it can be circumvented. Thus, not to speak of insects, the inland Giant Lizard (Conolophus) of the Galapagos Archipelago has learned to shake down the prickly fruits and eat them in spite of all their armour. How its gullet and stomach can stand the sharp and strong needles, we do not know. Similarly there are insects that enjoy the nettle, and it has been called one of the "natural vegetables." The tops are cooked by man as a substitute for spinach, and used to be in great repute, as Dr. MacGregor Skene reminds us in his "Common Plants" (1921), "for clearing the blood in spring."

Two Cautions.

The second caution is a little more difficult. Behind the use that spines and thorns, prickles and stings, and the like may be to plants, in saving them from the appetite of their enemies, there must be internal conditions of growth that lead to these peculiarities. Thus the tip of a long leaf, or a much elongated leaf, is apt to be poorly nourished and will therefore tend to harden. Spines and the like seem often to be symptoms of ebbing vitality, not necessarily of the plant as a whole, but of particular corners. Similarly, there can be little doubt that the sharp microscopic needles of one plant and the poisons of another are, to begin with, indications of some peculiarity in the chemical routine of the plant. But this is not inconsistent with their being protective against hungry animals. Here we should remember Alfred Russel Wallace's point that spines and thorns are most abundant where plant-eating mammals are most in evidence, and rare or absent in Oceanic Islands where native mammals are wanting.

Photo: John J. Ward, F.E.S.

STINGING HAIRS OF THE NETTLE—GREATLY MAGNIFIED.

In the common nettle (*Urtica dioica*) a short pillar of cells rises from the skin, and bears in a cup the bulbous base of the stinging hair, which tapers to a fine point. The hair is stiffened with a deposit of flint and the brittle tip has a deposit of lime. A touch breaks off the tip, the flinty tapering needle penetrates the skin, and pressure from the base injects a minute drop of the poison which is secreted in the swelling at the lower end.

XXXII

SHIFTS FOR A LIVING

ALL the world over we see so many shifts for a living among animals that we cannot get away from the impression of life as something difficult. It is a fight, a struggle, a rowing against the stream—unless indeed the creature drifts into parasitism.

It would be going too far to say that the physical world is unfriendly to living creatures, but it is callous and often menacing. To environing difficulties and limitations there are on the part of living creatures *answers back*—to changes in the physical conditions, to the competition of fellows, and to the aggressiveness of foes. The total clash constitutes the struggle for existence, and the tactics in the unending campaign are what we call "shifts for a living." Some are conscious and intelligent devices, others are expressions of hereditary instinct and do not require to be learned, while others are the outcome of enregistered reflexes, and may not need a brain at all. There are shifts for a living at many and different levels.

A sea-snail settles down on the arm of a starfish and begins to secrete corrosive acid from its mouth (sometimes dilute oil of vitriol !) ; the starfish cannot dislodge its enemy ; what it does is to surrender the arm and escape with its life. As the starfish has no brains or nerve-centres of any kind—only nerve-cells and nerve-fibres—we know that it does not deliberately give its limb for its life. What it does is done reflexly in virtue of pre-established linkages between certain nerve-cells and certain muscle-cells.

In the same way, but with more awareness and control, a crab gives off a leg that has been badly bruised, or that has been gripped by a powerful enemy. We have already noticed that in some kinds of crabs the surrender cannot be accomplished unless the tip of the limb be pressed against a rock ; in some related crustaceans the animal nibbles and pulls at its broken leg. The highest level at which the surrender of parts occurs is among lizards, where the tail is often left in the grip of the assailant. Here, as in the crab, there is a pre-arranged "breaking-plane," or there may be more than one. The new tail which replaces the lost one is often rather a makeshift.

Very interesting are those cases, regarding which very little is known, in which an animal appears to seek out a habitat where it is inconspicuous. Thus a spider with a particular pattern is often found on a lichen-covered surface precisely like itself.

We wish to distinguish cases where the animal selects its environment from the more familiar cases where the animal has a favourite and usual haunt, e.g., a particular kind of leaf, or flower, or bark, to which its colour and pattern have become in

Photo : John J. Ward, F.E.S.

PARASITE OF THE PIGEON. (Magnified twenty diameters.)

This is one of the wingless biting lice or bird-lice (Mallophaga), quite different from the true lice (Anoplura), which suck blood. They creep about among the plumage and nibble at the delicate portions of the feathers. They show a large head, short feelers, and a flat body ; the front legs hold food to the mouth, the others cling to the feathers.

the course of time adapted. Leaf-insects and walking-stick insects are familiar examples of creatures that have become like their habitual environment, just as the tasselled sea-horse has become like the waving seaweed among which it lives.

Animals, like the men of Athens in St. Paul's day, are always on the outlook for some new thing—unless, indeed, the species has settled down into very comfortable conditions of equilibrium. The pressure of population and the changefulness of the physical environment supply spurs to adventure, to which many an animal is naturally inclined. They are always looking out for some new niche of opportunity; they are always sending out what might be called *tentative tendrils*. Thus we find all sorts of strange habitats—a spider living inside a pitcher-plant, an earthworm up a tree, brine-shrimps in the Great Salt Lake of Utah, barnacles on the tail of a sea-snake, a score of animals in a coal-pit, a dozen in a hot spring, water-snails browsing on stones just on the verge of the Niagara Cataract, and thousands of animals in the eternal night of the Deep Sea. Or again we find all sorts of strange experiments in the quest for food—a woodpecker tapping the sweet sap of the sugar-maple, the Kea parrot devouring dead sheep, a dog-whelk browsing on acorn-shells, ants milking greenflies, the medicinal leech sucking blood, the leaf-cutter ants growing a palatable mould on a green paste made of chewed leaves, the crocodile-bird entering the reptile's mouth and picking his teeth, and so on through a very long list.

Photo: John J. Ward, F.E.S.

CATERPILLARS OF THE SWALLOW-TAIL BUTTERFLY (*Papilio machaon*).

One of these green and black-banded caterpillars is seen in the act of protruding its V-shaped scent glands, which produce a strong smell, like decaying pineapple, helping, perhaps, to drive away ichneumon flies and other enemies. The fleshy "horns," pinkish or orange in colour, are extruded from the front part of the ring nearest the head, but are not seen till after the third moult, when the caterpillar's colour changes from black to green.

Highest of all the devices which strengthen an animal's foothold is that of *sociality*. By which is meant not living together in great numbers, like a million mites in the cavern of a cheese, but forming some sort of coherent whole—whether it be herd or hive, rookery or ant-hill. It implies some degree of subordinating self, just as in a football team; it means a strong sense of kinship; it often includes certain conventions, such as giving a danger signal or answering an appeal for help. But our present point is simply that it pays, and not only in immediate success, but in progressive evolution as well. The success of the social ants, bees, wasps, and termites (on the instinctive line of evolution); of rooks, cranes, parrots, beavers (apart from man), elephants, and monkeys (on the intelligent line of evolution) is indisputable; it points to an open secret which man is slow to read.

The old naturalists often chronicled extraordinary stories, partly due to misunderstand-

ings, as in the case of mermaids, partly due to the generous acceptance of travellers' tales, as in the case of sea-serpents. But it would be easy to cap most of the old "curiosities of Natural History" with well-authenticated discoveries of to-day. The more intimate Natural History becomes, the more subtle does life appear, as Fabre's studies have showed so well. One of the reasons for the subtlety is the quietly urgent intensity of the struggle for existence, since necessity is ever the mother of invention. The other reason is an experimenting bent, which seems to us to be at the heart of the creature. In the midst of a non-living domain, more "friendly" perhaps than "unfriendly," yet fundamentally callous, living creatures are always searching after ways of avoiding death. Much more than that, indeed, they assert themselves insurgently, thrusting as well as parrying, multiplying as well as growing. We wish to refer to a very remarkable habit which illustrates this subtle insurgence of life.

Life Struggle.

In various insects belonging to different families there is a curious kind of behaviour which has been called "reflex bleeding." When the insects in question, such as the Blister Beetles, are irritated or alarmed, they eject a fluid which is excessively irritant. This fluid is for all practical purposes the blood, but it must be allowed that in insects the blood cannot be separated off from the fluid found in the general cavity of the body. This is a technical point, but of interest in regard to the curious case to which we wish to refer more particularly—the reflex bleeding of a troublesome blood-sucking tick that attacks pigeons and fowls.

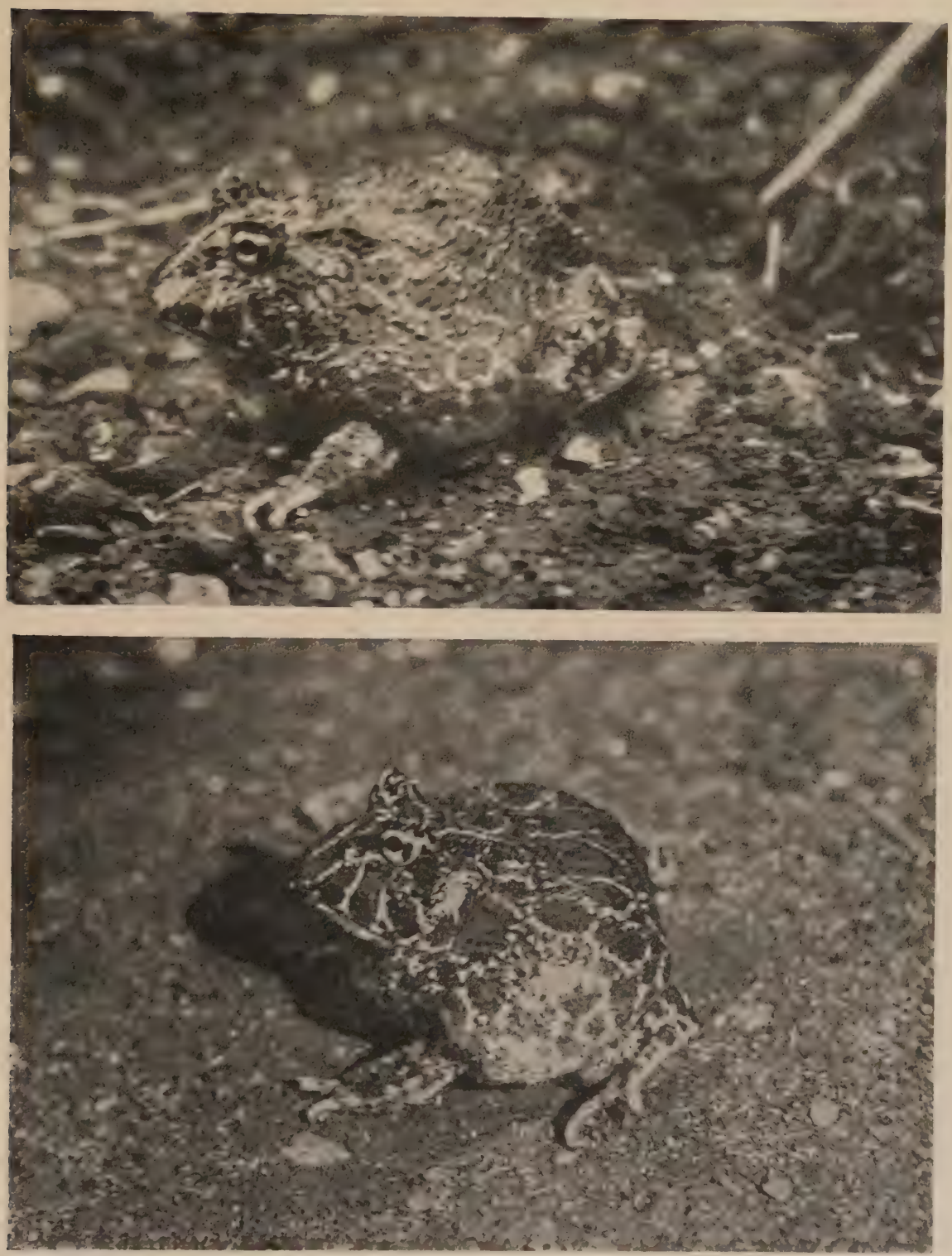
The Blister Beetle in Alarm.

When one touches a pigeon-tick (*Argas reflexus*) in an aggressive sort of way, it "feigns death," whatever that may mean. It folds up its jointed legs and "plays 'possum." But when the tick is more vigorously stimulated, by considerable warmth, for instance, it does something else. It ejects a drop of clear fluid from an excretory opening between the first and second pair of legs. Or two drops will be exuded if both sides are irritated. This is a sort of bleeding, and it has been proved that what is squeezed out contains the characteristic white blood corpuscles. The tick, irritated by heat, bleeds itself! The ejection of the blood is due to forcible muscular contraction of the cavity of the body, and the ejection is facilitated in moist surroundings and when the tick has had a big meal. In everyday life the tick makes an excursion on to the pigeon's leg, plunges its proboscis through the skin, and begins its meal. It gorges itself with blood, and it takes about thirty-five minutes to be satisfied. Then it pushes with its legs, draws out its suctorial apparatus, retires from the pigeon and seeks darkness. But a French zoologist, Dr. P. Remy, has been able to prove that very soon after the heavy meal, the tick begins to bleed. It contracts its muscles, and drops of its own blood issue from the spots indicated. There is some uncertainty whether there is an actual orifice at the spot (the so-called coxal gland aperture), or whether the opening is burst out at the time. In some less difficult cases it is known that the opening of the coxal gland is temporary, yielding to occasionally exaggerated pressure. In any case, it seems that the crystals formed by the evaporation of the fluid exuded serve to cork up the opening through which the bleeding occurs.

In various animals there is more or less forceful ejection of repellent fluid. Thus some millipedes exude an oily and malodorous substance when they are handled or hurt. It issues through minute pores, and it is probably a useful defence, all the more valuable since millipedes, unlike centipedes, have no poison. The obnoxious odour of bugs is well-known, and there are some of them frequenting plants that leave their taint on fruit, such as blaeberries.

Protective Ejections.

Some insects defend themselves by squirting out their blood, which may produce a blister or even an ulcer. Professor Doflein tells us of an Algerian locust that discharges its liquid shot to a distance of sixteen to twenty inches. It issues at a pore between the first and second joint at the base of the leg, the pore being opened by a special muscle when danger threatens. Similar joint-bleeding may be studied in ladybirds, oil-beetles, and many others; and there are various arrangements in different types, all adapted to the same end—the squirting out of a repellent fluid. One can study this on the energetic beetle called the Devil's Coach-Horse



Photos : F. W. Bond.

HORNED TOAD (Ceratophrys). UPPER FIGURE, AT REST ; LOWER FIGURE, EXCITED.

This big-mouthed, large-headed, greenish toad of South America is represented by several species, one of which attains to a length of six inches. They have the upper eyelid transformed into a triangular horn, which becomes more conspicuous during excitement. Often they half bury themselves, and are camouflaged by their resemblance to the soil and the grass, and thus they wait for a victim, such as a frog, to come fatally near.

Photo: John J. Ward, F.E.S.

DEVIL'S COACH-HORSE BEETLE (*Ocypus olens*).

This is one of the "rove beetles" (Staphylinids), often seen hurrying along the side of the road, especially towards evening. It looks as if it had no wings but they are stowed away under the very short wing-covers. It can fly quickly and far.

that runs about by the roadside, cocking up its tail when molested. Its wing-covers are so short that the wings have to be much folded to get under them. It is distinctly malodorous.

When the worker White Ants or Termites go on a foraging excursion they are in some cases accompanied by "soldiers," who serve in some measure for protection. They may defend the workers against attacks of the true ants, who are bold enough for anything. In some species the soldiers have a very remarkable artillery. Inside their head there is a bilobed gland from which a duct runs to an opening on the tip of the beak or rostrum that projects in front. When the soldier is on the offensive there is a rapid contraction of certain muscles on the sides of the head, and a jet issues from the beak. It consists of a clear fluid with a smell like cedar-oil; it is glutinous and resinous, and difficult to rub off. What the soldier does is to discharge this jet right in the face of an insulting ant, and it is extraordinarily efficacious. The ants that have received the fatal douche are seen running about as if demented, but often stopping to rub their faces with their fore limbs, or to rub their head against something. But they cannot get the stuff off, and they usually die. Here is a clear case where the material squirted out is not blood, but a specialised secretion, which appears to have this aggressive function and no other.

Soldier Termites.

On many of the swiftly-running Ground-Beetles (or Carabidæ) there are muscular reservoirs at the end of the food-canal, from which there can be spurted out an offensive discharge produced by special glands. The secretion is usually an acid of some sort; in certain cases it is said to contain butyric acid, which gives such a disagreeable odour and taste to rancid butter. Among these Ground-Beetles are the Bombardiers, where the secretion of the glands in question becomes instantaneously gaseous when discharged. This appears to be very irritating to enemies, and we know that drops of the secretion burn and mark the thick skin of man. When a little Bombardier-Beetle is held between the finger and thumb it gives off repeated discharges, marked by a smoke-like vapour, and a distinct popping sound. Hence the name. Mr. George Dimmock points out that if a Bombardier be compelled to discharge its secretion under water, the gas can be collected in the usual way in an inverted test-tube. In this fashion he collected from a Pyrenean species in a few moments an amount of gas equal to several times the space occupied by the beetle itself. For our present purpose what is most interesting is the high specialisation of a quaint mode of defence, strangely suggestive of the use of poison gas!

Bombardier-Beetles.

Photo: John J. Ward, F.E.S.

DEVIL'S COACH-HORSE OR COCK-TAIL.

This black beetle, rather over an inch in length, is very aggressive and defiant. It has strong jaws, and it can exude a repellent secretion from its tail end, which is always being cocked up excitedly. It feeds chiefly on other insects.

The Bleeding of the Horned Toad.

In desert places in Mexico, California and Nevada, there are strange squat lizards called "Horned Toads" or Phrynosomes. They are bundles of peculiarities, with sharp horns on the back of the head, a power of changing colour to that of the surroundings, and an unusual way of burrowing head-foremost. But perhaps the strangest of the peculiarities is the habit of "shedding tears of blood." Of course this is not literally true, for this queer lizard can neither "weep blood" nor "spit blood," as it is often credited with doing. What happens is this. When the creature is badly excited there is a rush of blood to the head, the pressure rises, the eyelids are congested and swell to twice or thrice their normal size, and then a fine jet of blood shoots out for several inches from below the upper eyelid. There is a hæmorrhage, *perhaps* because the animal is suffering from shock or fright or rage, *probably* because there is an increase in the production of hormones from the suprarenals, and *possibly* because the jet of blood is a surprise to the enemy.

The Pigeon Tick Again.

We are now in a better position to consider the drop of blood that is squeezed out from the pores of the tick. It is not likely to be defensive or offensive, as in the insects to which we have referred. Dr. Remy put a drop of it on the cornea of a guinea-pig's eye, and there was no caustic effect. There is no proof that the blood of the tick is poisonous.

Dr. Remy's suggestion is that the Argas ticks and their relatives, which do not reside on the animals they bleed, take a large meal of blood when an opportunity occurs. They have long fasting periods, more or less compulsory, sometimes lasting for six years; and naturally enough they make the most of a meal. It is not every day that a tick can get on to a pigeon's leg. Their food-canal becomes gorged with blood; the pressure in the cavity of the body increases till it becomes inconveniently high. It is then that the tick, quite reflexly, gets rid of some watery blood from the coxal apertures. It is probable that fluid from the pigeon's blood in the tick's food-canal diffuses into the cavity of the body, and thence out, accompanied by some of the tick's own blood. It may be that extra salts from the pigeon's blood are also got rid of in the same way. In

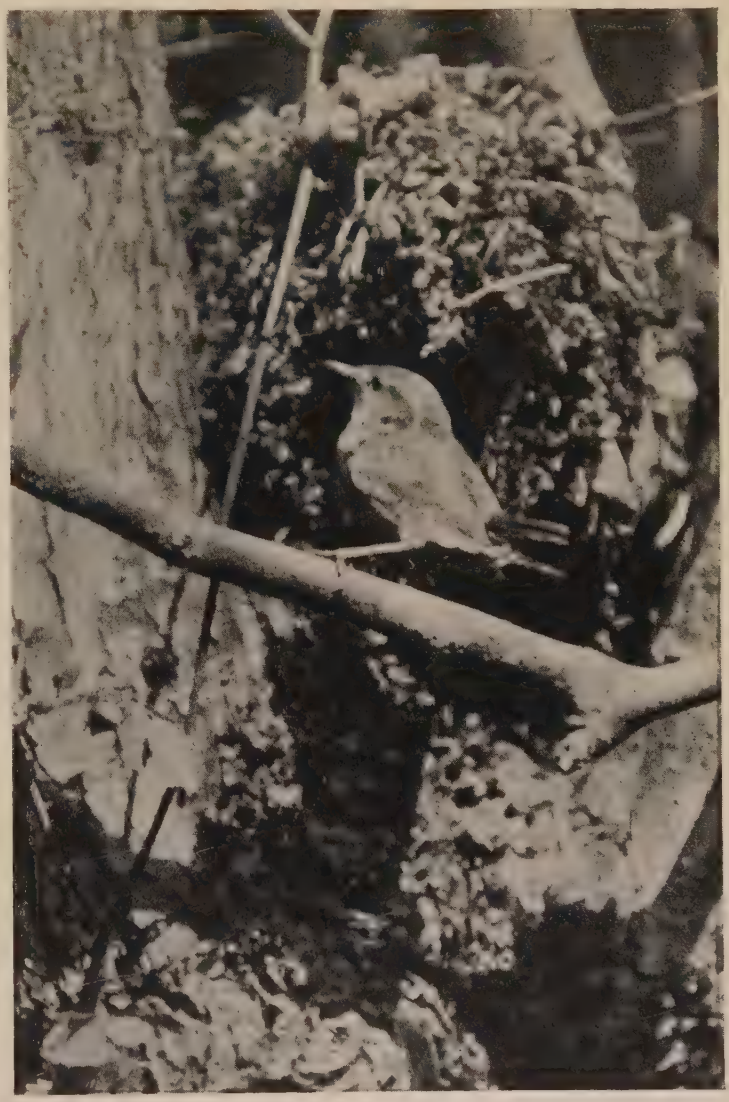


Photo: T. M. Blackman.

WREN AT ENTRANCE OF NEST.

The ordinary round nest of the wren is relatively large and often rather conspicuous. Withered leaves and lichens often form the outside, and the interior is lined with hair, feathers and moss. Five to eight dainty eggs are laid in April, white or slightly speckled; and there is often a second brood.

Photo : M. H. Crawford.

NEST OF WREN.

The wren's nest is usually completely domed and it may also be well protected by its position in a hole in a wall or in a tree trunk. Extra nests are often built, by the cock bird at least; but the meaning of this is obscure.

short, the excretory aperture is a safety-valve. But our main purpose was to illustrate along a curious line some of the strange habits that have been evolved in the course of the ages of intense struggle for existence.

The Story of the Wren

We get another light on the battle of life when we think of some of the little creatures that hold their own although defenceless. A good example is the Common Wren. When we walk round our garden in the winter we always see wrens flitting about and we sometimes hear the cocks singing a little. They dart out from the bushes and the ivy on the old wall, are visible for a fraction of a second and then disappear. They are safe in the struggle for existence, not by keeping in concealment or by being shy, but because of their restlessness. If there is any bird that can be in two places at once it is the wren. Of course they are also saved by their minuteness, but that would not avail if they were not so agile. The wren's technical name means "cave-dweller" (Troglodytes). But while the wren shelters in holes or caves, including its own domed nest, we should think that its characteristic was rather in spending so much of its time in the open. It does not live a hidden life. To put it technically, we mean that it is not a *cryptozoic* bird. It can do the vanishing trick, but self-effacement is not in the wren's character.

The Egg of the Wren.

In his well-known exultation over the beauty of common things, Walt Whitman tells us that "the leaf of grass is no less than the journeywork of the stars, and the ant is equally perfect, and the grain of sand, and the egg of the wren." Many another egg would

Photo : G. H. Hewison.

YOUNG WREN, ONE DAY BEFORE FLIGHT.

An interesting feature in the life of wrens is their occasional return to an old nest for shelter, especially on winter nights. It would be interesting to know if the birds that return are family parties going back to their cradle.

Photo: C. Reid.

COMMON WREN (*Troglodytes troglodytes*).

This familiar but elusive bird is common throughout Europe, from the sea-coast to the high moors. It takes swift, short flights with its tiny rounded wings, and seems to have confidence in its power of rapidly making itself invisible almost anywhere among herbage or bushes.

Photo: John J. Ward, F.E.S.

YOUNG WILLOW-WRENS RESPONDING TO THE CALL-NOTE OF THE MOTHER BIRD, RETURNING TO THE NEST WITH A CATERPILLAR.

Willow-wrens or willow-warblers (*Phylloscopus trochilus*) are not in any way related to true wrens. They are among the commonest of the summer visitors to Britain. The general colour is greenish-yellow, and the birds are easily lost among the foliage. The nest is partly domed and usually on the ground. The young birds call insistently when they are hungry, and are mostly fed on small caterpillars.

serve equally well to illustrate the finish of workmanship that is characteristic of Animate Nature, but a wren's clutch is hard to beat. Properly speaking, we should not see the eggs at all, for they lie hidden in a domed nest, but they are wonderfully dainty—about three-fifths of an inch in length by half an inch across, white, with faint reddish dots. Not infrequently there are eight of them, and the schoolboy of long ago becomes young again now when he thinks of putting his finger into the feather-lined ball and trying to count the tiny eggs. What a large laying for so small a bird!

The beauty of the wren's egg is different from the beauty of a wren's nest, for that is a masterpiece made by living artists who express themselves in their achievement, whereas the egg is the outcome of unconscious vital processes, comparable to those that result in the shell of a periwinkle. Round the yolk and the drop of living matter that rests on it, round the enveloping white of egg, and round the tissue-paper-like membrane enclosing all, there is formed, in the oviduct of the mother bird this delicate and yet substantial shell. The lime, which is secreted in fluid form, hardens rapidly under finely balanced conditions of pressure; and little dots of pigment are usually painted on just at the nick of time—so is formed one of the daintiest of eggs—a masterpiece in miniature. The shell is not living as a feather is living; yet it is an expression of the orderliness and balance of vital processes.

The domed nest is very large for the size of the bird, and it varies considerably in composition according to the materials available. Typically, it is a spherical structure with a door at one side, and it is made of grass, moss, bracken, leaves, and the like, finished off with feathers inside, when it is to be used as a cradle. It is well known that wrens may make a home of their nest after brooding is over; indeed, they sometimes shelter in wintry weather inside a nest that belonged to some other bird. The two parents share in building the nest, in the patience of brooding, and in the hard work of feeding the large family with small insects. In a covered-in nook the roof of the nest is sometimes dispensed with, but there is usually a complete dome. It is dainty work, showing skilful use of materials; it is very effective for its purpose; and its beauty is in part an expression of the fine feeling of the birds themselves.

Many of us are very familiar with wrens up to a certain point, for there are often several pairs in one garden, especially when there is an ivied wall suitable for nesting. But it is not easy to understand them; they are mentally on lines very different from ours. It is certain, however, that wrens have a very fine nature. The cock's whole-hearted song shows this: he sings even with his tail, and he sings far beyond the courting time, which is always a sign of a pleasant disposition, to say the least, and perhaps a sign of grace. Another pleasant feature is that the male bird is "a braw fighter." He goes into battle with a song and often leaves the field singing. We believe that the rivals sometimes sing even as they fight.

The combative cock is also a very domesticated paterfamilias. He takes his full share in all duties; and it is a pleasant feature that the parents may be seen attending to their young ones after these have left the nest. This is the more interesting, since there are often two broods in the year. There must be a sociable disposition in the wren, for there seems no doubt that a number may take shelter together in the wintry season—sometimes in an unlined nest.

No doubt the wren has a very sound constitution. It is instinct with energy and good spirits. It has a very wide geographical distribution in Europe and beyond. It can stand a winter in Aberdeen. It is found on the tops of mountains and on uninhabited islets off the coast. It can fly across the North Sea if it wishes to, and it is not unwilling to take a lift from a sailing vessel going its way. The wren has courage, some would even say impudence.

It seems to us that the wren illustrates three kinds of beauty. First, the egg of the wren is beautiful, for it is the outcome of harmoniously rhythmic, wholesomely balanced, vital processes. Life is a kind of activity that turns out beautiful things. Second, the nest of the wren is beautiful, for it is the deliberate yet spontaneous workmanship of an instinctive artist. Third, the body of the wren is beautiful, for it is the long result of time, from which all the discordant and discrepant has been winnowed away. It is a living unity, inspired by a delightful personality.

We could spend years studying the wrens in our garden; there are so many things we should like to discover about them. We should like to know how many pairs there are and whether they are faithfully monogamous; we should like to know whether all of them were born in the garden, or in the vicinity, or whether some come every winter from the Continent; we should

Photo: John J. Ward, F.E.S.

EGGS AND NEST OF WILLOW-WREN (*Phylloscopus trochilus*).

The nest of the willow-warbler or willow-wren is usually built on the ground, but there are many exceptions. In most cases it is made of grass, but mosses and pieces of fern may also be used. It is a difficult nest to find. There are six to eight eggs white blotched with red, usually laid in May.

like to know what insects they eat in winter or what they eat when they cannot find any insects; what their relatives are among other birds, whether with tree-creepers or possibly with water-ouzels (though Professor Newton said this was "absurd").

There are many questions that we should like to ask and answer besides those we have mentioned. How has the wren such an enormous voice for so small a body; what is the secret of its voice-production? What does it mean by building extra nests—one lined with feathers and the others unlined? Thanks to Miss Turner and other bird-observers of the first rank, we know that the unlined nests are usually, perhaps always, the work of the cock-bird only, that he may use one of them as a shelter, that the young birds may be transferred from the true nest to the "cock's nest" after they have got on a bit, that the adults may use the unlined nest as a winter house, and that an unlined nest may be after a long interval raised to the level of a lined nest. This is very interesting. It may be noted that the different chapters in a bird's "breeding cycle" are sometimes lengthened out or shortened down—sometimes dropped out altogether. A life-history is sometimes like a tune which can be sung "quick time" or "slow time," or with parts left out. Just as the cuckoo has telescoped its nest-making and brooding chapters altogether, so it may be that the wren has lengthened out the nest-building chapter. When it can be done so perfectly it must be a satisfaction in itself to make a beautiful domed nest of grasses and leaves and mosses and lichens; and we do not wonder at the proud male saying to his mate: "Why, you like that? I'll build you another one." And so he sings, and singing builds.

Another of the questions we should like to ask the wren and a few other birds, like the water-ouzel, is about singing all the year round. It is such a private question that we must ask it very quietly, and of the birds themselves, rather than of the ornithologists. As usual it is the male bird that sings; as usual he sings best when he is most in love. Like many other cocks, he uses his vocal powers to rouse the interest of his desired mate and to tell her what he thinks of her. As is common, he also uses his voice to send a ringing challenge to his rivals. He is so fond of his music that, like a happy warrior, he goes singing into battle and sings as he fights. But our question is in regard to the overflow of song into the other seasons—even winter. Is the wren simply a constitutional Mark Tapley—vigorous, hardy, eupeptic, very successful, ranging from Ireland to Persia, from the Faeroes to the Atlas Mountains? Or dare we think that the wren is one of those rarer spirits who suggest to man that love is a finer and bigger thing than fondness, and may become independent of times and seasons?

A simple study in brown and grey, the wren seems when we get a glimpse of it, but close inspection reveals an intricate beauty of bars and spots. There are little white spots on the tail and wing-coverts which the male shows off when he is courting—not that he has anything to display which his mate does not herself possess. Now the expert bird-observer tells us that "after the wear and tear of family life these small white dots become obliterated." Which things are a parable; but what we are asking leave to emphasise is that the male wren's song does not wear thin. Resident bird though he is, he knows no winter in his soul.

The popular natural history of the wren is open to criticism. Many people hold to the absurd idea that Cock Robin and Jenny Wren are man and wife, and some quote Scripture in support of it, citing the text, never preached from, "The robin and the wren are God's cock and hen." Both birds enjoy some safety under the shield of this kindly superstition, but both are very well able to look after themselves. We fancy that the robins in our garden are always glad to see us, and one will certainly follow us—even into the house. But we have no such illusion in regard to the wren. It is not afraid of us, but it is not glad to see us; it is never more than inquisitive. Yet we are reminded of the North American *Troglodytes domesticus*, which comes much about houses in the country, provided there are no English sparrows about. A well-known American naturalist, Dr. Hornaday, of the New York Zoo, says that even the cats of his country household used to respect the family wrens. "I never knew of a wren being killed by anyone save a collector of bird skins. As for myself, I would go wrenless for ever rather than take the life of a creature so winsome and trustful."

XXXIII
THE WAYS OF BACKBONELESS ANIMALS

THERE have been three *very* successful lines of animal evolution: (1) that of JOINTED-FOOTED ANIMALS or ARTHROPODS, with their climax in ants and bees, spiders and scorpions, crabs and lobsters; (2) that of MOLLUSCS, with their climax in cuttlefishes and snails; and (3) that of BACKBONED ANIMALS or VERTEBRATES, with their climax in birds and mammals. These three lines of evolution are very different from one another, expressing, as it were, different ideas. The Jointed-Footed Animals or Arthropods have ringed or segmented bodies with many limbs or appendages; they have an outside non-living skeleton made mainly of a very resistent material called Chitin, to which lime is added in crabs and lobsters and the other Crustaceans; this outside covering (or cuticle) has to be periodically moulted as long as the growth of the body goes on, for it cannot grow itself, being without living cells; and the limbs have the muscles inside the skeleton, not outside, as in backboned animals. The Molluscs have no limbs at all; the body is not ringed; their shell is usually rigid, composed of lime and a material called conchin; and it does not require to be moulted, for additions are always being made to the free edge as the animal inside continues to grow. The Vertebrates may have an outside skeleton, such as the scales of fishes and reptiles, but this may be absent, and, in all ordinary cases, it is unimportant compared with the internal skeleton

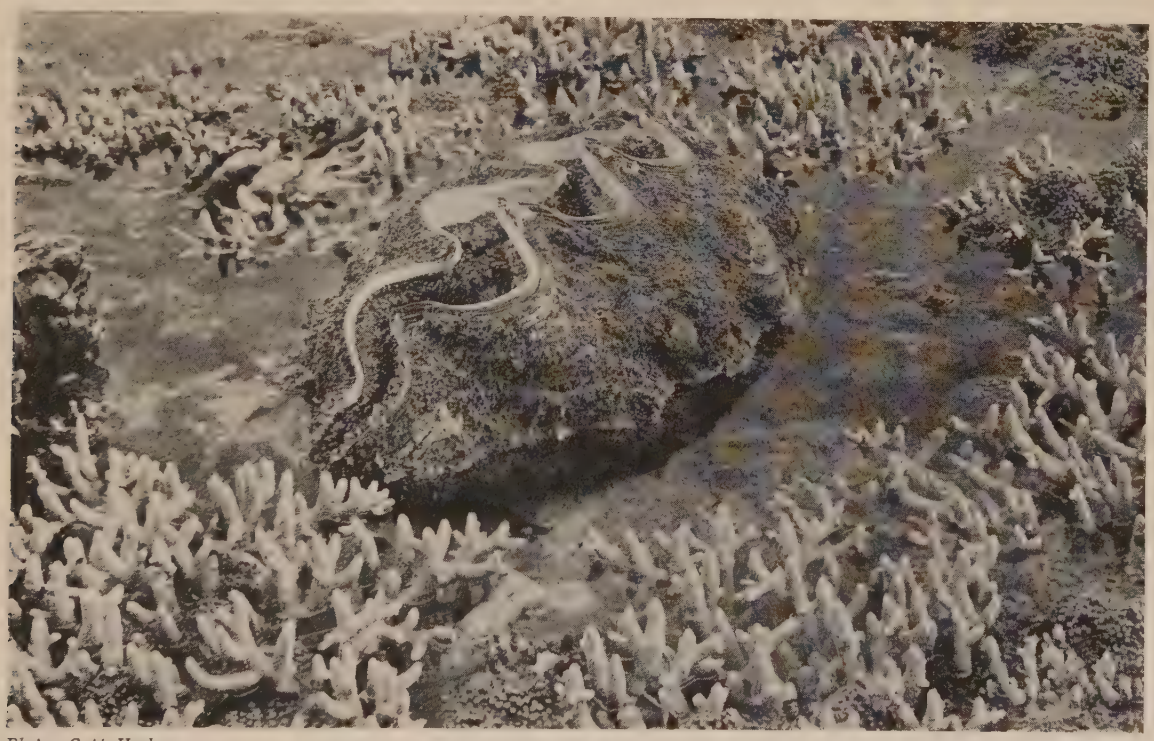
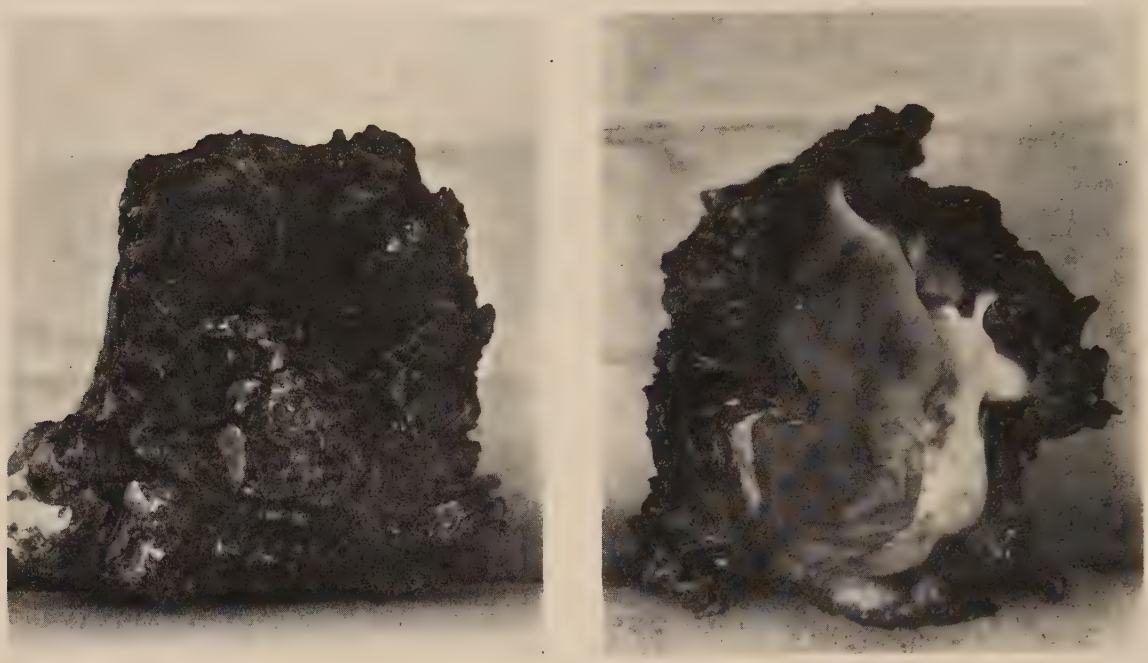


Photo: Capt. Hurley.

GIANT CLAM SURROUNDED BY CORAL, SHOWING THE INTERLOCKING MARGINS OF THE MASSIVE SHELL-VALVES.

These large bivalves (Tridacna) live in the shallow water of eastern seas, and are very sedentary. Two valves of *Tridacna gigas* in the British Museum weigh respectively 154 and 156 pounds, and the edible flesh may weigh 20 pounds. The shells are sometimes broken to form knives and axes, and they make beautiful Holy Water fonts. The muscles are so strong that a man's hand or foot may be fatally imprisoned.



Photos: John J. Ward, F.E.S.

DEVIL'S CLAW OYSTER.

A large black "oyster," a species of Avicula, nearly related to the pearl oyster Meleagrina. The opened shell shows the mother-of-pearl.

—the skull, the backbone and ribs, the limbs, and their supporting girdles. In most cases this inside skeleton consists of bone which never occurs among Invertebrates. The limbs are limited to two pairs; and there are many other important characteristics, such as the dorsal brain and spinal cord.

In former parts we have given examples of the ways of Backboned Animals, and we turn now to the sub-kingdom of the Backboneless. Here the variety is so great, and the number of classes so large, that our method of selecting a few illustrative cases is necessarily inadequate. The gaps will be filled, however, in later parts of the book. We begin with Cuttlefishes and other Molluscs.

The group of Molluscs includes: (1) Bivalves, like cockles and mussels, oysters and clams; (2) Gastropods, like land snails and slugs, whelks and periwinkles; and (3) the Cephalopods, including the cuttlefishes and Nautilus. On the whole, they are slow-going creatures, with a great deal of slowly-contracting or unstriped muscle, such as occurs on the wall of our food-canal. Although cuttlefishes, slugs, and sea-butterflies have practically no shell, most of the molluscs are weighted with very substantial encasements.

A Slow-going Race.

The Giant Clam or Tridacna is often too heavy for a man to lift, and a single valve makes a big bath for a baby. Naturally enough, then, many molluscs are very sluggish. Oysters and mussels are practically sedentary after their juvenile free-swimming stage is past; a limpet makes only short excursions on the shore-rocks in search of palatable seaweed; and the beautiful Pearly Nautilus, though sometimes seen at the surface, usually lives sluggishly on the floor of the sea, at depths of 300–600 feet. But the sluggishness which is the rule is not without its exceptions. The dainty "sea-butterflies," which form a great part of the food of whalebone whales, are free-swimming, open-sea Gastropods. The common scallop (Pecten) swims by clapping its two valves, and there is a beautiful bivalve called Lima, not uncommon in the Firth of Clyde for instance, which swims now and then at a good rate, with orange-coloured tentacles streaming out behind. It is interesting also since it lives habitually on the sea-bottom inside a nest of pebbles and mud loosely glued together.

But it is among modern cuttlefishes or Cephalopods that we find the most remarkable emancipation from the sluggishness which must be regarded as fundamentally characteristic of Molluscs. Many of the cuttlefishes (squids

especially) swim as rapidly as fishes, and the shape of the body when swimming is sometimes remarkably fish-like. Of course the word cuttlefish is a mere popular name, for Cephalopods are not in the remotest way related to true fishes. But the point is that out of a sluggish race there have evolved, with gradual suppression of the shell, very active forms like squids—molluscs that can actually catch fishes!

Photo: F. W. Bond.

FLAT-COIL WATER SNAILS (Planorbis).

There are many different species of Trumpet Snails (Planorbis) common in freshwater pools, able to breathe both at the surface and under water. Some make excursions among damp grass, and some can survive a long period of drought, during which they close up their shell with a lid. They have red blood.

Movements of Squids.

An ordinary squid (e.g., Loligo) has three ways of moving. It can creep along by means of its tentacles or arms, which bear numerous gripping suckers. Two of these arms are much longer than the other eight, and can be shot out to catch a passing fish, as Aristotle noticed more than two thousand years ago. Secondly, the squid can swim head-foremost, moving in the water by means of the muscular triangular fins at the posterior end of the strangely shaped body. Thirdly, there is a kind of locomotion peculiar to cuttlefishes, the effectiveness of which has to be seen to be believed. Behind the head there is a wide opening leading into a spacious "mantle-cavity," where the two gills lie. When this cavity is full of water the aperture is quickly and neatly closed by a remarkable hook-and-eye arrangement. The mantle or outer wall of the cavity is then contracted, and the water, which cannot go out where it came in, is forced through a narrow outlet, called the funnel. This gush of water, rhythmically repeated, drives the squid along, with the posterior tip of the body in front, and the arms pressed together behind. The triangular fins, which are leading in this quaint kind of locomotion, quite unique in the animal kingdom, seem to be used in steering. The swimming is helped in the squids and in Sepia by an interesting *internal* vestige of the external shell,

Photo: M. H. Crawford.

EGGS OF FLAT-COIL TRUMPET SNAIL (Planorbis).

The eggs are laid in a flat gelatinous mass attached to the under surface of water weed, and there may be twenty to forty in a clump. One of the commonest species in Britain is *Planorbis corneus*, about an inch in diameter.

Photo: W. S. Berridge, F.Z.S.

BLACK SLUG (*Arion ater*).

This handsome animal may grow to be four inches long, and varies from the normal black to brown and red and other colours. Although characteristically vegetarian, it often eats animal matter. The shell is reduced to a few granules of lime on the back.

within which the ancestors of modern cuttlefishes were wont to live. In Sepia this relic is a fairly substantial wedge of spongy lime, the "Sepia-bone" or "Sepiostaire," which is given to cage-birds to peck at. In the squid the relic is a long, chitinous blade or "pen," a little like an old-fashioned quill. In both the vestigial "shell" is quite hidden, but serves as a sort of axis, which consolidates the body in swimming. In the less active Octopus, there is no vestige at all, except that the embryo, as in all Molluscs, has a transient microscopic shell.

The Cloud of Ink.

Relinquishing a shell, as the cuttlefishes have done, means the possibility of greater freedom, but it involves the exposure of the body to assault. Thus we look for compensations, and we find them in the sucker-bearing arms or tentacles, which are often very formidable weapons. In the case of a big Octopus or other "Devil-Fish," they may be dangerous to man himself. The perfect sucker is somewhat cup-like, with a marginal ring of chitin furnished with gripping teeth; there is an internal piston which is raised when the sucker is pressed against the skin of the victim; this raising produces a partial vacuum and the grip is very tenacious. The marks of huge suckers, as big as tumblers, are sometimes seen on the skin of a whale.

There may also be some value in the remarkable power of colour-change which cuttlefishes often exhibit. The octopus is often well adjusted to the corner among the rocks where it lurks. In other cases the colour alters according as the animal is pleased or displeased. As in fishes, the change of colour is due to the contraction or expansion of the numerous pigment-cells (chromatophores) in the skin.

Noteworthy also are the very strong jaws, closely resembling the beak of a parrot; and their efficiency is increased by the poisonous secretion of the posterior pair of salivary glands opening into the mouth.

But there is a unique protection in the power of discharging ink, a quaint way of throwing dust in the eyes of assailants! The sepia ink, which was formerly used by painters, is a waste product which accumulates in a bag at the end of the food-canal. Its discharge is due to an automatic (reflex) contraction in moments of excitement. It can be seen in a very young cuttlefish a minute after it escapes from the egg

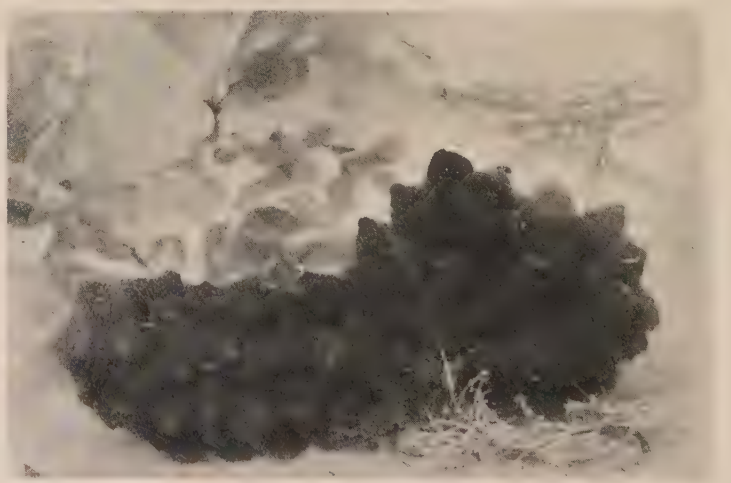


Photo: W. S. Berridge, F.Z.S.

EGG CLUSTER OF SEPIA (*Sepia officinalis*).

The eggs of Sepia are known as "sea-grapes" and are usually attached to seaweed. Each egg has a separate black capsule containing a jelly, but the stalks of the capsules are united. What hatches out is a fully-formed miniature of the parent.

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

COMMON SEPIA.

This common cuttlefish (*Sepia officinalis*) has ten sucker-bearing arms, two of them much longer than the others, and used in catching prey. The length of the body, apart from the arms, is often about eight inches, which is not large for a cuttlefish. The photograph shows one of the eyes, a lateral "fin" along the body, and, below that, the funnel through which water is squirted out for locomotor purposes.

envelope, thus illustrating what is meant by an inborn reaction, like our ability to sneeze. In natural conditions when the cuttlefish is in danger it may escape in a cloud of ink, which acts like a smoke-screen in naval warfare, save that it is under water. We see, then, that modern cuttlefishes have many compensations for the loss of the shell.

Many of the cuttlefishes, such as squids, liberate their eggs in gelatinous tubes, which are fixed to seaweed; in other cases, such as octopuses, the eggs form a branched bunch and deserve their name of sea-grapes. The development is telescoped down, with an omission of the free-swimming larval stages which are usual among aquatic molluscs, and out of the egg envelope there comes a fully-formed miniature of the parent. We see the same sort of suppression of juvenile or larval stages in the land snails and slugs, but for a different reason. For a thoroughly terrestrial animal that lays its eggs in the soil, could not have free-swimming larvæ.

The Argonaut.

To the question, why should there be no larval stages in cuttlefishes, it is more difficult to give an answer. The suppression has probably to do with the fact that there are comparatively few eggs, with a good deal of nutritive legacy in the form of yolk, and that risks are lessened by launching the offspring as fully-formed vigorous youngsters able to fend for themselves.

In the female Argonaut or Paper Nautilus, a cuttlefish of the Open Sea, two of the arms are expanded into webs, and secrete a fragile shell of great beauty, which is used as a cradle for the eggs and for the young.

The shell differs from that of the Pearly Nautilus in not being chambered, and in being not a house, but a cradle. It also differs from every other molluscan shell in being a product of two arms, and not of the mantle or skin-fold. Another peculiarity is that the shell is unrepresented in the male, who is a pigmy compared with his mate, not that she can be called big. The shell begins to be formed in the female while she is still very young, perhaps ten or twelve days old, and it is gradually added to as she grows. It will be understood that as the shell is non-living, it cannot grow of itself; it is added to by the arms. The old notion that the Argonaut raises her webbed arms to form

Photo : W. S. Berridge, F.Z.S.

FEMALE PAPER NAUTILUS (Argonauta), SEPARATED FROM ITS SHELL, CRADLE. ONE OF THE SHELL-MAKING ARMS IS SHOWN IN THE LEFT UPPER CORNER.

This Argonaut is found in all warm seas, including the Mediterranean. Unlike the pearly nautilus, to which it is not nearly related, it is an open sea animal. The male is much smaller than the female and shows no trace of the shell, as is natural enough since the shell is a brood-chamber.

a sail is entirely without foundation—notwithstanding poems and pictures to the contrary.

The Cuttlefish Mind.

Cuttlefishes have a relatively large central nervous system of a molluscan type and well-developed eyes, which bear a striking superficial resemblance to the eyes of Vertebrates, though they are developed in a very different way. There are structures sensitive to smell and touch, and there are also ear-like organs which seem to help in balancing. But it is not possible to say much as yet in regard to the mind of cuttlefishes. They are effective in capturing their prey, and some of those that have been watched in aquaria have shown persistence and daring in the pursuit of what they wanted. The fact is that cuttlefishes are so well equipped for their ordinary life that instances of intelligence outside everyday efficiency are difficult to find.

Cuttlefishes and Sea-Serpents.

We cannot turn away from this glimpse of cuttlefishes without noticing that they have been the foundation of some of the best sea-serpent stories. The arms of some kinds (Architeuthis) have been known to attain a length of forty feet, to which have to be added ten feet for the body and head. If this huge creature were to launch itself half out of the water, as cuttlefishes sometimes do, there would be the beginning of a very presentable sea-serpent. On the Irish Coast, a specimen was once caught with tentacles thirty feet long and eyes fifteen inches in diameter. Larger forms occur on the American coasts. A big piece of a scale-covered cuttlefish was obtained by the late Prince of Monaco from the stomach of a sperm-whale. As the kind of cuttlefish to which it belonged has not yet been found, we are warned not to be too dogmatic about what the sea does or does not contain. In any case, the cuttlefishes are among its masterpieces.

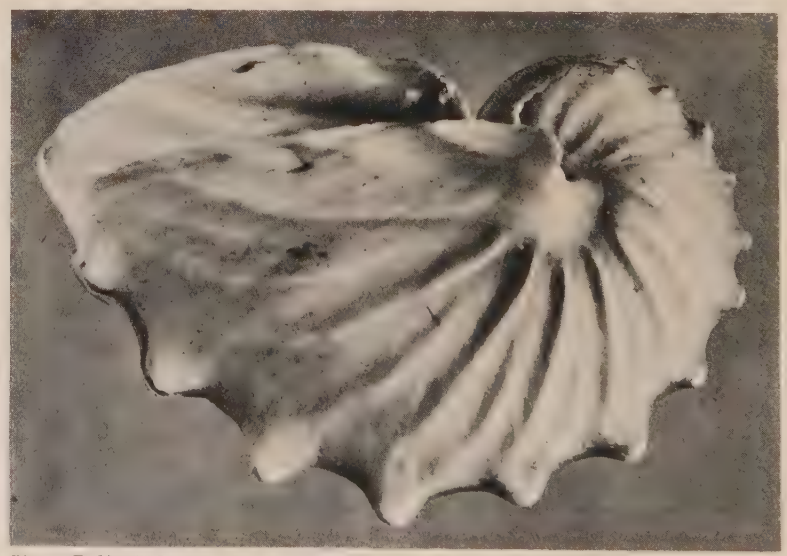


Photo : F. Martin Duncan, F.R.M.S., F.Z.S.

SHELL, MADE BY THE FEMALE PAPER NAUTILUS (Argonauta).

This beautifully sculptured shell has only one chamber and is made by the female only as a secretion from two of her arms. It is used as a cradle for the eggs and young ones ; yet it begins to be formed about ten to twelve days after the young female Argonaut is itself hatched.

Photo: John J. Ward, F.E.S.

SHELLS OF THE PEARLY NAUTILUS (*Nautilus pompilius*), ONE HALVED, ONE INTACT.

The pearly nautilus is the only living Cephalopod that has a shell that can be used as a house. In the halved shell the small initial chamber may be seen in the centre. As the animal grows it adds chamber after chamber, always shutting off a fraction of the previous chamber and drawing itself forwards. A pipe, partly membranous and partly calcareous, runs from chamber to chamber. Only the last chamber is inhabited; the others are full of gas. The nautilus is not uncommon in the seas off such places as the Moluccas, Fiji, and New Hebrides. It lives on the bottom in comparatively shallow water, and creeps about in search of animal food. After storms it is sometimes seen on the surface.

The Ways of Bivalves.

In the large class of bivalves—cockles and mussels, oysters and clams—the head region is undeveloped and the nervous system is of a low order, with little centralisation. They are mostly sluggish as regards locomotion, and live an unadventurous life, shut up in their shells. The cockle sometimes makes little jumps along the sand, and the freshwater mussel ploughs its leisurely furrow in the mud of the river. No doubt all bivalves do a prodigious amount of *internal* work, for the living lashes, present in thousands on the gills and lips and skin-folds, keep up currents of water which carry in oxygen and microscopic food and sweep out waste. But their *external* work is slight.

When a freshwater mussel keeps its young ones in the cradle of its gills and does not let them escape until a minnow or some other fish comes swimming past—a story which we tell in the part dealing with Life-Histories, it is doing a very effective thing, for the young ones cannot grow up without sojourning for a time on the minnow or some similar bearer. But no one would dream of calling the mother-mussel intelligent. It is constitutionally so built that it retains its young ones till the passing fish unconsciously gives the signal. The fish is the key that opens the door, but the mussel does not *think* about it.

An oyster sometimes closes its valves tightly on an intrusive starfish, and cases are known of an inquisitive rat being caught in this way at very low tide, but it is safe to say that the oyster did not *mean* to do it. It was a reflex, not a reflective action. "Learning" is perhaps beginning when oysters that are being artificially reared become accustomed to longer and longer periods of exposure out of water. They keep their shells shut, retaining enough water to be

Photo : F. W. Bond.

EGGS OF BRAZILIAN LAND SNAIL (*Borus oblongus*).

The eggs are like the eggs of a small bird, and it will be seen that what is hatched out is a fully-formed miniature of the adult animal. In other words, there is a complete suppression of the larval stages that are seen in freshwater and marine snails.

Photo : F. W. Bond.

BRAZILIAN LAND SNAIL (*Borus oblongus*).

These land snails belong to the same family, Helicidæ, as the common garden snail. The upper longer horns bear the eyes, which are able to detect quick movements ; the lower shorter horns are also sense-organs, for touch and perhaps smell.

Photo : M. H. Crawford.

GARDEN SNAIL, SHOWING REPAIRS TO BROKEN SHELL.

The garden snail (*Helix aspersa*), one of the most familiar of animals, the cause of many disappointments to the gardener. It wanders in a leisurely way for considerable distances, leaving a trail of mucus which marks its path, and often shows that it can return to its original starting-point.

going on with. This is a profitable thing to do, and the fitness of it is not contradicted by the fact that the oyster-farmers on the French Coast lengthen out the period till the oysters keep their valves closed all the way to Paris.

The Education of a Snail.

It has been shown that limpets on the seashore rocks sometimes return to their particular corner after they have been on an excursion after food. The advantage of returning to a particular spot is plain in those cases where the margin of the limpet's conical shell fits the surface of the rock with precision, and thus enables the animal to retain water when the tide goes out. When the rock has a more or less flat and uniformly smooth surface, the advantage of returning to a particular spot or " scar " is not so great. Perhaps this may explain why some limpets do not seem to show any " homing " tendency. Among those that " home " it has been noticed that the distance from which they can regain their " scar " is limited to a few inches. On the other hand, one retentive individual seemed to " know its way home " from a distance of four inches after the interval of a fortnight. The probability is that the limpet builds up a topographical memory of the immediate surroundings of its own particular " scar."

It appears to be well-established that a garden snail can find its way home from a distance of six yards. Of one that habitually spent the day in a hole in a garden wall, it is recorded that it continued for months utilising as a nocturnal ladder a piece of wood sloping from a bed of herbs to near the hole. Perhaps it followed its own trail.

Darwin mentions in " The Descent of Man " the case of two Roman or Edible Snails, one sickly and the other vigorous, which were placed in a garden ill-provided from the snail's point of view. The vigorous one went over the wall and found abundance next door. After twenty-four hours' absence it returned to its companion, and in a short time both disappeared over the wall. This is the sort of observation that one would like to see repeated with precautions, but it is probably safe to use it as indicating at least some topographical memory. One would like to know whether the first slime-trail may have

Photo : M. H. Crawford.

GARDEN SNAILS IN THEIR WINTER LETHARGY.

About the month of October, when the snails are in good condition, they hide themselves in a hole in a wall or burrow into the loose soil, and close the opening of the shell with a lid of slime and lime, thereafter sinking into a state of suspended animation.

counted for something in the return journeys. Land snails have a sense of smell, though its seat remains uncertain.

Very interesting experiments have been made by Miss E. L. Thompson on an American water-snail (*Physa gyrina*) which glides about in ponds, mouth and creeping sole upwards, suspended to the surface film. The method of research was suggested by the ingenious experiments on dogs devised by Pavlov, a famous Russian physiologist. A dog's mouth waters at the sight or smell of food, and it is possible to measure the quantity and quality of the secretion. If a whistle is blown or some colour is displayed when the food is exhibited, the dog registers the association so thoroughly that in the course of time the sound or colour serves *of itself* to evoke the mouth-watering. The shadow works like the substance. Miss Thompson found that when the snail's mouth was touched by a little piece of lettuce or the like, the creature made a number—about four was common—of rapid mouth-movements. But whenever she presented the food she also pressed the snail's foot with a clean glass rod. She thus accustomed them to the two touches at the same time, and she continued until they were " trained " to link the two together. She then gave the snail class a rest for forty-eight hours, after which she tried the touch on the foot by itself without any food. The dux of the class gave the proper munching answer the first seven trials right away, and others also did well. Some made less than the usual number of mouth-movements, and after ninety-six hours none would give any answer at all. But the general result is clear, that an animal of humble rank learned a lesson. Even the worm will turn, even the snail will learn. It learned to link together a food-touch to the mouth and a glass-touch to the foot, so that by-and-by it showed the mouth munchings when the foot was pressed, although no food was there. It was a lesson in association, but it did not last long.

Miss Thompson also tried whether the snails would learn the right way and the wrong way to the surface. She fastened a Y-shaped glass tube in the aquarium, with one arm rough and leading to a slight electric shock, and with the other arm smooth and leading to the surface of the water where the snail gets fresh air. The roughness of the wrong tube was meant to be a " warning." The air was pressed out of a snail's breathing chamber and the creature was then placed at the base of the Y-shaped tube. It was, of course, of value to the snail to get its lung refilled as soon as possible. This would be attained by creeping up the smooth arm; the other arm meant failure and a mild punishment.

But the snails showed, so far as this experiment was concerned, complete incapacity to profit by experience. As the trials continued the percentage of mistakes did not diminish. It seems then that snails can learn in some cases but not in others. It is highly probable that in the course of their individual experience in natural conditions they learn to associate certain external signs with the palatability and unpalatability of various foods.

If we are to understand even a little of the long inclined plane of animal behaviour we must be clear that forming a simple association is a long way below the level of intelligence. If a bell is rung whenever food is put into the cage where tame mice are kept, they will gradually, though not very rapidly, learn to come scampering whenever the bell is rung, even though there is no food. The force of the association is too strong for them. Everyone knows that the chickens will come running when they hear the familiar call that they have learned to associate with a meal. We have known a cat in a new home " learn " in a few days to come hurrying downstairs at the sound of a dinner-bell of which it had, before the flitting, no experience; but in this case the " learning " was so rapid that there is reason to suspect that there was something beyond forming an association.

Associations.

In typical cases of association-forming, such as Pavlov's dog and Miss Thompson's water-snail, a stimulus that has no particular interest in itself, becomes closely linked to a significant stimulus, as the sight or the touch of food, and likewise with the subsequent effective behaviour. They occur together so often during the process of learning that in the course of time the insignificant stimulus pulls the trigger of the effective action. This is a physiological not a psychological fact, if we can separate the two aspects, neither the dog's nor the snail's mind was at work.

EDIBLE SNAILS (*Helix pomatia*).

The edible or Roman snail (*Helix pomatia*) occurs in some parts of the South of England, and is common in France and Italy. It is much larger than the garden snail (*Helix aspersa*), and is a strong vigorous animal with a large vegetarian appetite. Only the anterior body and the muscular ventral surface or foot can be protruded from within the shelter of the shell.

Photo: John J. Ward, F.E.S.

When the snail shows itself from within its shell it—

Photo: John J. Ward, F.E.S.

first protrudes its head—

Photo: John J. Ward, F.E.S.

then the upper pair of horns bearing its eyes.

Photo: John J. Ward, F.E.S.

Now it is ready to pull itself forward by its muscular "foot."

XXXIV
SPIDERS: THEIR WORK AND WAYS

UNLESS one has a prejudice—not always easy to overcome—one cannot but admire spiders. Their ways are quaint and original; they are very skilful artificers; they have "sought out" many inventions, such as snares and webs; some of them make journeys through the air on threads of gossamer; others make a trap-door nest in the earth; one of them makes a web under water and fills it with dry air like a diving-bell. On a summer day we may sometimes watch a spider making a silken suspension bridge across a narrow stream, and after the bridge is finished a web is stretched across.

It is easy to convince oneself that spiders are not nearly related to insects. Thus the body is divided into two great regions instead of three (head, thorax, abdomen), the spider's head being always soldered to the thorax, whereas the insect's head is always free. There are four pairs of legs, whereas an insect has three pairs. A spider has no wings or feelers, and there is always a pair of poison-claws in front of the mouth. There are many other differences, but we have said enough to show why we must not think of spiders as insects. They are not even nearly related.

Not like Insects.

As to habits, there is good reason for thinking that the average spider is more intelligent than the average insect. It has, like the insect, a wonderful bundle of ready-made tricks or instincts, which do not require any apprenticeship, making a web, for instance; but it seems to

Photos: John J. Ward, F.E.S.

GARDEN SPIDER (*Epeira diadematа*).

The garden spider is unsurpassed in its workmanship. The left photograph shows it gripping the line with its two hind feet as it travels downwards, bridging a gulf. In the photograph to the right, the spider is moving along a twig back downwards, holding on with its claws.

Photo: M. H. Crawford.

GARDEN SPIDER AND HER EGG-COCOON.

The garden spider lays hundreds of eggs in autumn and surrounds them with a ball or cocoon of golden silk threads, fastened in a crevice of the bark of a tree or under a twig or a fence bar. Sometimes the young ones develop quickly, sometimes they are not hatched till spring. When they come out they huddle together in a living ball, and if this is disturbed they drop down on silk threads, climbing up again when the crisis is over.

close to her. She retrieves her treasure by smell, not by sight. Similarly, a spider does not usually see the fly that struggles on the web; it feels the vibrations. The fact seems to be that vision does not count for a great deal in the everyday life of the spider. A beautiful web can be made in the dark, and some spiders are most active at night.

When we think of spiders we are apt to picture a rather dingy brown creature like the common House-Spider. But in warm countries there are very numerous brightly coloured kinds, many of them like living jewels. It would not be difficult to select a dozen spiders that would compare well with a dozen tropical butterflies or a dozen humming-birds. In the courtship of some brightly coloured spiders there is often what looks like a display of gay clothing. This suggests that the eyes of spiders can distinguish and appreciate colour. And it has been proved by experiment that some spiders show a distinct preference for certain colours. Thus there is one which picks out red surroundings if they are available.

have more freedom, more initiative, more to fall back on if it fails with its first endeavour.

The Senses of Spiders.

The eyes of spiders, which may number half a dozen, are fixed on the top of the head, and they differ from those of an ordinary insect in having only one lens each, just as in our own eyes, whereas the eyes of ordinary insects have hundreds of lenses. Spiders' eyes are simple; insects' eyes are usually compound. Spiders are very short-sighted, and a mother seeking for the cocoon that has been stolen from her does not seem to see it even when it is quite

Photo: John J. Ward, F.E.S.

FOOT OF GARDEN SPIDER, SHOWING THE HAIRS AND THE COMB-LIKE CLAWS—HIGHLY MAGNIFIED.

The presence of these small teeth on the claws enables the spider to lay hold of smooth surfaces and to manipulate the silken threads.

Photos: Hugh Main.

A TRAP-DOOR SPIDER (*Nemesia congener*).

Left.—Door of burrow closed; concealed with pieces of leaf. *Right.*—Door of burrow open, showing the female just inside.

The burrow of this trap-door spider is particularly interesting because it is Y-shaped, with a second door at the fork. The branch or side-aisle does not reach to the surface, but serves simply as a retreat if an intruder gets down the shaft. Only the females sink a shaft.

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

HEAD OF MALE HOUSE-SPIDER (HIGHLY MAGNIFIED), SHOWING DOUBLE ROW OF EYES.

The arrangement of the eyes differs considerably in different kinds of spiders and is a useful aid in identification. Unlike the compound eyes of most insects, those of spiders have only one lens each, and are very short-sighted. The house spider (*Tegenaria domestica*) makes only a cobweb, which is not viscid. The photograph shows the poisonous jaws (chelicerae) in front of the mouth, and outside these the somewhat leg-like sensitive pedipalps, which are swollen at the tip in the males, and used in pairing.

There are smelling bristles on various parts of a spider's body, and they are certainly important. But the sense that counts for most is touch, which has its seat in sensitive bristles at the ends of the legs and on the second pair of mouth-parts (the pedipalps). The sensitiveness of our finger-tips does not approach the touchiness of a spider. For it can distinguish different kinds of vibrations made on the web, and act accordingly. It can distinguish the struggles of an entangled wasp, who is not welcome, from those of a fly, always welcome, and from those of another spider of the same kin, who may or may not be welcome. The spider lives in a world of touches and tremors.

It is difficult to devise experiments which will separate off sensitiveness to delicate vibrations from true hearing, that is to say sensitiveness to sound-waves. But numerous careful trials point to the conclusion that spiders are not aware of sounds.

At present (1925) it cannot be said that hearing organs have been *proved* in spiders. But it is possible that they occasionally occur and have escaped detection. A good reason for being cautious is to be found in the fact that a big Bird-Catching Spider (Mygale) of India gets up on its two hind pairs of legs, shakes the others

Specially drawn for The Book of Knowledge by Roland Green, F.Z.S.

EPEIRA INSULARIS

This common American spider, probably the same as the European *Epeira quadrata*, shows very clearly the distinction between the web and the nest. The web is a large circle which may be over a foot across. A special trapline leads to a nest of rolled leaves situated on a twig above the web. Within this nest the handsome spider sits, holding the trapline in an eight-stretcher limb.

in the air, and produces a peculiar and loud noise. "It resembles that made by pouring out small shot upon a plate from a height of a few inches, or, perhaps, by drawing the back of a knife along the edge of a strong comb." It is produced by both males and females, and it is caused by rubbing a scraper on the second last joint of the pedipalp against a hard comb on the basal joint of the same appendage (the second in front of the mouth). There is also a Swedish spider that makes a sound, confined to the male. Now, if an animal voluntarily makes a sound, it is *likely* that it can hear. But there is evidently need for further inquiry.

Sheer Dexterity.

Many things done by spiders prove their great sensitiveness to tremors, and that is why we began with the senses. But many other pieces of behaviour deserve the word *dexterous*. As we lie awake in the morning, when we should be up and doing, we sometimes see a spider creeping along the ceiling above our head. This is such a familiar sight that we think nothing of it. But the spider is defying gravity! It is walking along with its legs up and its back down. It is holding on by means of a little group of very

Photos: John J. Ward, F.E.S.

EGG-COCOON OF A SMALL BRITISH SPIDER (*Theridion pallens*).

This very tiny spider makes a cocoon larger than itself, a conical structure of white silk, with peculiar projections. It fastens the cocoon by its broad end, but shifts it about with great skill so that the developing eggs are sunned. The size of the cocoon is about a quarter of that shown in the photograph. There are many of these Theridion species, about seventeen in Britain; they are very common in the summer time on bushes, where they make irregular webs. The globular abdomen is well shown in the photograph. Some of the common American line-weavers belong to this genus.

It seems, then, that we must be very cautious in regard to the stories about spiders coming down from the ceiling to listen to music. Much more probable is it that they are affected by vibrations quite different from sound-waves. One of the stories is that when Beethoven was a boy and used to play his violin alone in his room, a spider would let itself down from the roof and sit on the instrument. When Beethoven's mother discovered this appreciative audience she killed the spider, whereupon Ludwig broke his violin. When, in after years, the great musician was asked about the truth of this story, he said that he remembered nothing about it, but that everything, even spiders, "would have fled before his terrible scratching."

small toothed claws at the tips of its legs. In the Bible (Proverbs xxx, 28), mention is made of the spider "laying hold with its hands," but some say that the word translated "spider" refers to a lizard called the gecko, which has adhesive pads under its toes and often runs up walls. If the reference is to the spider, it quite well describes the way the curiously bent claws grip the roughnesses on such a surface as the whitewashed ceiling. The spider does lay hold with its hands.

If a flake of whitewash should break off, it is not likely that the spider will fall, for it has eight legs altogether. But even if it lost hold

Photo : Hugh Main.

BLACK-BELLIED TARANTULA (*Lycosa narboriensis*) OUTSIDE BURROW.

The name tarantula is used rather loosely, and is applied, for instance, to various "wolf spiders," belonging to the family Lycosidæ. The species that is photographed here is common in Southern Europe, and in bygone days its bite was said to induce a dancing mania.

with all its legs, it has another resource. If it quickly touches the ceiling with the tips of its spinning-organs (spinnerets) at the hind end of its body, a jet of liquid silk oozes out and hardens instantaneously. As the spider sinks, it pays out more line. It is an extraordinarily neat and dignified device. But that is not all.

Apart from any breakage of whitewash or any accident whatever, a spider may come down from the ceiling on a voyage of discovery. We have often watched this—a careful descent from the roof towards our face. We have seen the spinner stop halfway in mid-air, as if to reconsider its project, and then climb up again, leaving no thread hanging. In this case, the spider coils the thread round its palps, and, eventually, we believe, eats it. We have known of a man climbing up a rope hand over hand, but we never heard of him putting the rope into his pocket as he ascended. The spider's behaviour is surely worthy of being called dexterous gymnastics.

A little must be said in regard to the silk. It is made in numerous minute silk-glands inside the spider's body. Each is like an elastic syringe, and when the muscular wall contracts a jet of liquid silk is forced down a delicate duct, which opens on a bristle called the spinning-spool. These spinning-spools are borne by two to six knob-like structures,

Photo : Hugh Main.

BLACK-BELLIED TARANTULA (*Lycosa narboriensis*)—FEMALE WITH HER FAMILY ON HER BACK.

This handsome spider produces a large number of eggs, and these are carried about in a silken cocoon. But when the young spiders are hatched out, the egg-bag is discarded, and the minute creatures ride about on the mother's back for about a week.

Photo: Hugh Main.

BLACK-BELLIED TARANTULA SEEN AT HOME.

The photograph shows a vertical section of the somewhat rough-and-ready burrow or retreat that is made in loose earth.

each somewhat like the rose of a watering-can. But whereas the holes on the rose of the watering-can lead into a common pipe, each of the spinning spools on a spinneret communicates by a separate duct with a microscopic silk gland inside the spider's body. It is important to understand this clearly, for it explains how the spinner can make threads of different thicknesses. The strength of the thread depends on the number of silk-bags (glands) called into activity. It must also be noticed that there are often, as in the Garden Spider, two or three different kinds of silk. We say "as thin as gossamer," but a thread of gossamer is produced by *a multiple jet of liquid silk*, hardening instantaneously into the familiar delicate filament, which we hardly feel when it is wafted gently on to our face.

What are these spinnerets? The answer is rather interesting. They are transformed posterior limbs, giving us a good example of the origin of novelties from very old things turned to a new use. Spiders are descended from Jointed-Footed (Arthropod) ancestors with numerous posterior limbs, such as Centipedes show. In the embryo spider within the egg there are several posterior limb-foundations, and it is usual for three pairs to turn into spinnerets. Those that do not turn into spinnerets are short-lived structures that soon disappear. But they are tell-tale evidences of a distant past when the ancestors of spiders had numerous posterior limbs.

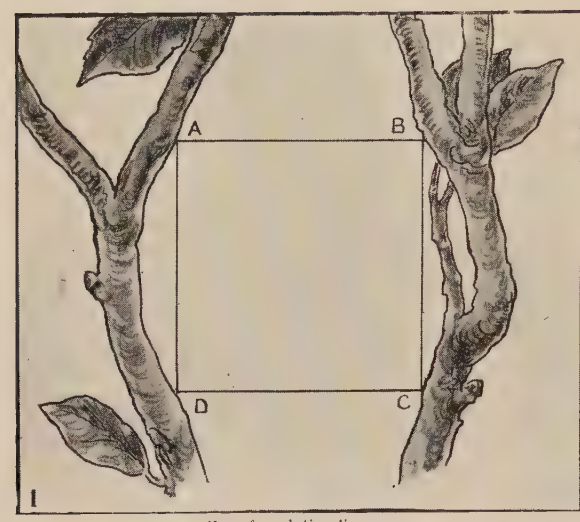
But what concerns us more in these Natural History studies is the fact that whenever spiders are in a difficult situation they pay out a drag-line. When a spider is walking along the top of a wooden fence, give it a gentle push, and you will be likely to see that, before it has time to fall, it has begun to pay out a drag-line, one end of which is glued to the railing. This habit of paying out a drag-line may be taken as the starting-point in making snares among the grass, which point the way to true webs; in weaving a cocoon around the eggs; and in spinning the long gossamer-threads that are used in ballooning through the air.

Photo: Hugh Main.

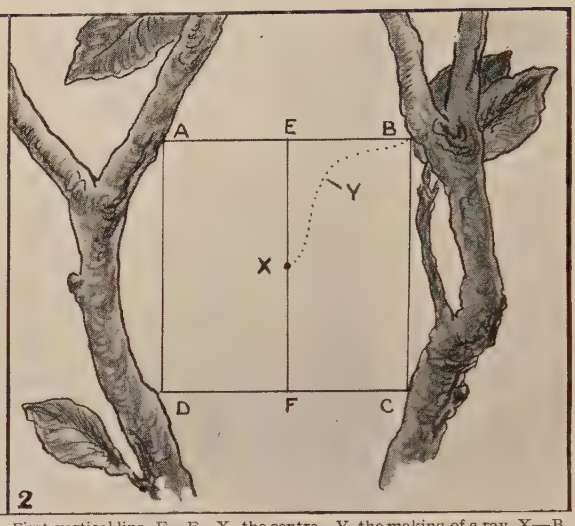
BLACK-BELLIED TARANTULA AT THE TOP OF ITS BURROW.

The shaft is excavated in loose soil and the interior may be consolidated with silk threads. Around the opening there is sometimes a definite parapet of small pebbles.

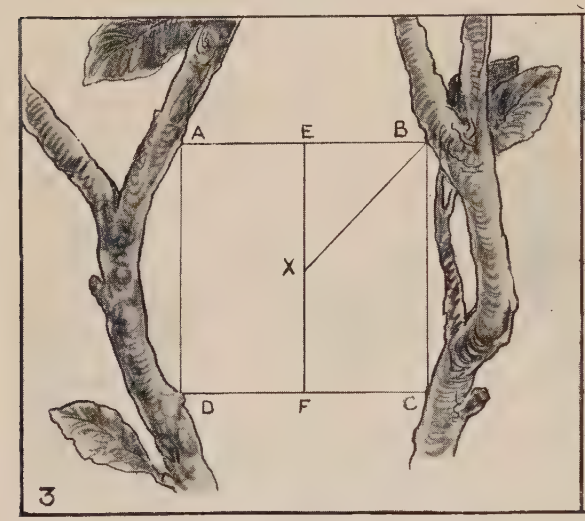
DIAGRAMS OF WEB-MAKING



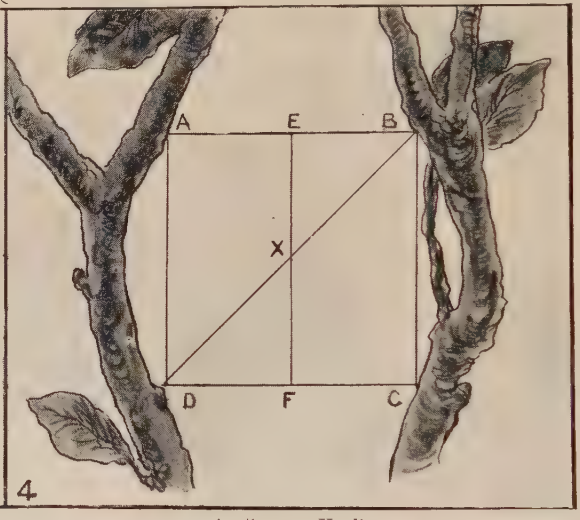
Four foundation lines.



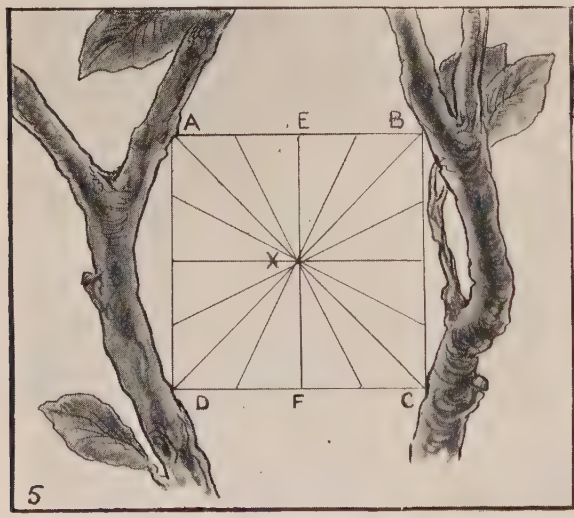
First vertical line, E—F. X, the centre. Y the making of a ray, X—B.



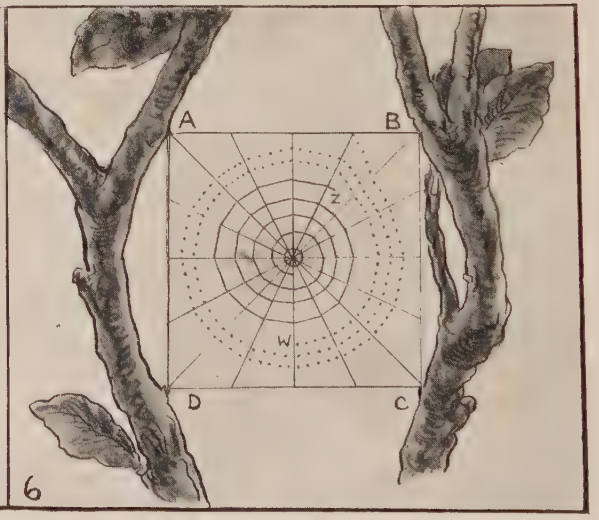
X—B, drawn taut.



Another ray, X—D.



More rays are made, first to one side and then to the other, so that there is no unequal strain. And now the spider commences the final stages of the structure.



Dark spiral the primary spiral—a scaffolding partly removed, stopping at Z. Dotted spiral the viscid secondary spiral just begun, stopping at W.

Photo: S. Crook, F.N.P.S.

ORB-WEB OF GARDEN SPIDER (*Epeira diadematа*)

In contrast to the diagrams, this is a photograph of the unsurpassable web of the garden spider, showing the upper foundation-line, the finished viscid web, and the spinner waiting events in the hub of her system. Sometimes she leaves the dry central platform and makes for a retreat close at hand, carrying a signal thread with her, so that she can distinguish the various kinds of vibrations in the web.

The Story of the Spider's Web.

A drag-line tangled among the leaves of grass might be useful in capturing insects, and a snare is little more than mesh of threads without particular arrangement. But some of the threads are sticky with drops of insect-lime. From a snare it is easy to pass to a cobweb such as we often see in the top corner of a stable. It differs from a true web in being little more than an irregular sheet of threads. The third grade is well represented by the beautiful orb-web of the Garden Spider (*Epeira diadematа*). Let us think over its making, shown in the diagrams on page 332.

The first chapter is laying *the foundation lines*, which enclose the chosen area. They are made specially strong, for they may be used over again if the web breaks down. The spider pays out a drag-line from A—B, and pulls it taut ; and so from B—C, C—D, and D—A, supposing there are four sides.

The second chapter is *making the rays*. From the middle point (E) of A—B, the spider drops down to the middle point (F) of C—D, and pulls the drag-line taut, as a sailor would say. That line E—F is the first ray. Then the spider climbs up FE. but pauses at the middle point X, the future centre of the web. It must have some sense of proportion. From the centre it climbs up to E, paying out a line, but keeping it from entangling with FE. It walks along to B, continuing to pay out, and then pulls the line taut, thus making the third ray, XB. Back to the centre it goes, and begins again to spin a thread. It walks down to F and along to D, and pulls the fourth ray straight. We need not continue further. Many rays are made, and in such an order from side to side that the centre is not pulled out of position.

The third chapter is *making the primary spiral*. Starting from the centre and taking

Photo : F. W. Bond.

BIRD-CATCHING SPIDER.

This is one of the large hairy spiders, many of which get the name Mygale. They live in warm countries under stones or in holes in trees, where they make a slight web. They hunt at night and very occasionally they pounce upon a small bird, which succumbs almost instantaneously to the poisonous bite. The largest known spider (*Theraphosa leblondi* of Guiana) belongs to this family, and has a body length of about three and a half inches; the leg span is much more.

rather big steps from ray to ray, the spider lays down a spiral, which is glued to each ray as it crosses. But this first spiral is not sticky.

The fourth and last chapter is *making the second spiral.* This is laid down from the circumference inwards, and is the final web, the first spiral being used as a scaffolding only. In making the second spiral the spider takes shorter steps, and the thread that is clamped on ray after ray is sticky. It is covered with minute droplets of what look like dew. As the web is completed, the spinner removes the first spiral, eating it up in point of fact.

From the hub of the web there is usually a special thread going to the nest, which may be round a corner, and by the vibrations of this thread the spider is made aware of the character of the visitor. We have often brought a spider out from the nest by twirling between our finger and thumb a thread of sewing silk with a tiny fragment of cork at the lower end, and allowing this to touch the web from time to time. Sometimes a spider seems to hold the web-nest line rather tightly, and then let it suddenly go, which may make the fly's entanglement doubly sure.

There are many different kinds of webs, some upright, and others horizontal, some like tents and others like domes; and sometimes it is necessary to distinguish between the web itself and the external scaffolding which keeps it trim and taut. But what are we to think of the achievement? Is it the outcome of an inborn gift, or of intelligent skill? There can be no doubt that in the main the making of the web is instinctive. For the very first time a grown-up spider makes a web, it makes one after the fashion of its kind. Its architecture is true to pattern, but the weaver does not deliberately follow any pattern. It weaves as to the manner born. The female spiders make the finer webs, but they are all equal. The males are usually smaller, sometimes much smaller, but their standard, so to speak, is not so high. It must be noted that a fine web can be made in a dark box, in the course of a few hours, and by a spider who never made one before. This is the mystery and miracle of instinct!

But is there no intelligence at work in the making of the web? The answer must be, we think, that glimmers of intelligence are to be discovered when there is something peculiar in what is done—some departure from the usual routine. Thus a web in a gusty place, between two rocks on the seashore, may show very interesting special lines which keep it from being blown out of place. Sometimes minute pebbles are fastened by silken ropes to the lower margin of a vertical web, so that it is kept more or less taut, just as we sometimes have a heavy roller fastened to the foot of a lantern-screen.

We sometimes find a flat web with foundation lines stretching right across a stream, from the bushes on one side to those on the other; and the question rises how such a problem has been

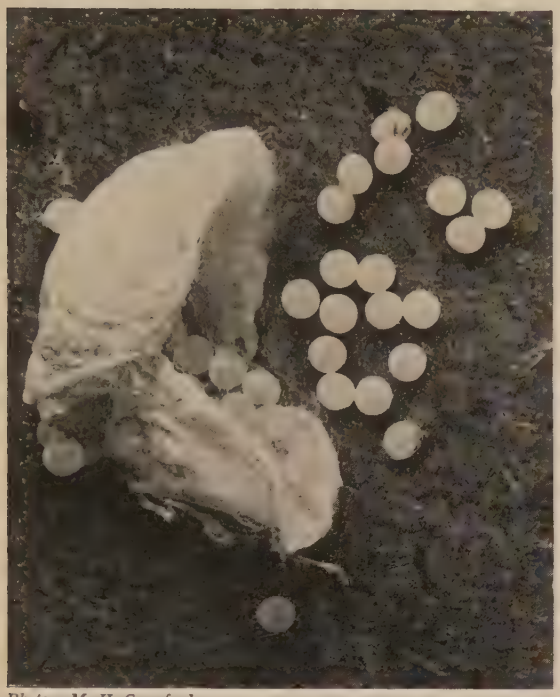


Photo: M. H. Crawford.

EGG-COCOON AND EGGS OF HOUSE-SPIDER.

From 60 to 100 eggs are laid at a time, and the cocoon is fixed in a safe corner. It is here shown highly magnified.

Photo: Hugh Main.

EGG-COCOON OF BANDED SPIDER (*Epeira fasciata*).

The globular silken bag is suspended from grass or twigs and is well concealed amongst the herbage.

Photo: E. J. Bedford.

WOLF SPIDER WITH EGG-COCOON ATTACHED TO HER ABDOMEN.

The Lycosids or "wolf-spiders" are wandering hunting spiders, making no snare or web, sometimes burrowing, sometimes without any home. The mother carries the egg-bag or cocoon with her as she journeys, and vigorously defends it against all her enemies.

Photo: E. J. Bedford.

EGG-COCOON OF FAIRY-LAMP-MAKING SPIDER (*Agræca brunnea*).

The elegant cocoon of this British spider is hung from grass or heather, or the like, by a short stalk. It is a quarter of an inch in diameter, and contains about fifty yellowish eggs attached to the roof, but in a short time the mother spider plasters it over with moist earth and closes the opening below.

Photo: M. H. Crawford.

SHEET-WEB AND TUBULAR RETREAT OF THE AGELENA SPIDER, IN A SAGE BUSH.

The Agelena spiders of numerous species make closely woven sheet-webs in bushes and on the banks of ditches. The threads are extremely fine and are strewn one upon the other until the muslin-like sheet becomes opaque in its whiteness. In its silk-lined tube the spider lurks, but rushes out whenever an insect lights on the sheet. The mouth of the tube is shown dark in the photograph.

solved. Standing on a high twig, the spider pays out a long line of silk, the free end of which is gradually pulled by the wind till it entangles on a bush on the other side of the water. Then the spinner feels that there is no longer any tug on her spinnerets, and she stops spinning. Ever so gently—here, perhaps, there is some intelligent judgment — she pulls the line straight and fastens the near end firmly to the twig. Then she ventures across the frail swinging line, paying out a second line which joins on to the first. If she gets across safely, the line is twice as strong as it was, and the journey may be made several times. When one line is secure, there is no great difficulty in making a second parallel to it, a short distance off, and then others going crosswise, till there are firm foundation-lines for the web proper.

Bridging a Stream.

There is a pretty story, told by Dr. Goeldi, of a Brazilian spider, common in gardens, whose web for a long time escaped discovery.

An Early Morning Spider.

A boy-naturalist, Dr. Goeldi's son, undertook to watch the spider through the twenty-four hours in the hope of solving the puzzle. He discovered that the spider made its web in the small hours of the morning, and that it caught small insects (male scale-flies) that flit about very early or very late. When the sun rose the spider unfastened its web, full of booty, folded it carefully up, put it on its shoulder, and carried it to the nest, where the contents were dealt with at leisure.

Photo: Hugh Main.

THE CLOTHO SPIDER (*Clotho turandi*).

The wall of the silken tent has been turned back to show the female inside.

Specially drawn for this work by Roland Green, F.Z.S.

NEST OF THE TREE WASP (*Vespa sylvestris*).

The nest of this common wasp is often built on the branch of a tree or bush. One comb is hung on to another by vertical supports, and the whole is covered by the multiple papery envelopes which keep out the rain and keep in the warmth. The inside temperature may be twenty-five degrees Fahr. higher than that outside. The cells are open at first, for the grubs have to be fed; but the full-grown grub spins a cocoon and closes the mouth of the cell with a projecting silken cap

XXXV

SOCIAL LIFE OF INSECTS

LIFE in a bee-hive goes on all the year round, though very nearly lulled to sleep in the winter months. Summer is the busy time. On a warm summer day, when the air is sweet with the scent of flowers, the work of the honey-bees is in full swing. From the hive comes a murmur that tells of activity within, while the threshold is thronged with workers.

There is a constant coming and going. Bee after bee sets off to the gardens and the fields, to forage—not for herself, but for the community to which she belongs. These outdoor workers are the strongest bees; the younger and weaker ones are "house-bees." Back come the foragers from the fields, and some of the house-bees are ready to meet them, and relieve them of their loads. Many different loads are brought to the hive. Some bees bring full sacs of honey to add to the store; others carry pollen, of every shade from palest gold to russet-brown, neatly packed in the two "baskets" on their hind legs; while others still have been to the pools in search of water.

A Bee-hive in Early Summer.

The house-bees take charge of the spoils, and pack them away in the storehouse of the combs. If a bee comes in, with pollen covering all her hairy body, house-bees are ready to comb her down and collect the precious dust. Collecting and storing, this is an important part of the work, but there are other necessary labours that can be noticed at the gateway of the busy city. Loads are brought out of the hive too, all manner of waste material, and the bodies of dead bees, for everything must be kept clean and orderly inside. Intruders such as slugs, too big to carry out are covered over with wax. The air must be kept fresh, too, so bands of workers act as fanners. Rows of bees stand motionless except for their ceaselessly beating wings. They are drawing the stale air out of the hive, and letting a current of pure air rush in. The fanning also helps to evaporate water from the honey, making it "riper." As the fanners get tired, their places are taken by other workers.

Near the hive, bees may be seen flying about in the sunshine, and taking no part in the carrying to and fro. These are drones or male bees, which do not share in the work of the hive, and, indeed, even beg for honey from the busy

Photo: G. H. Hewison.

HONEY BEE GATHERING POLLEN FROM LEOPARD'S BANE (Doronicum).

From some flowers the bees collect the nectar, which they change into honey, and from others they collect pollen, which is chiefly used as food for the grubs. But there are some profitable blossoms that supply the bees with both.

Photos: G. H. Hewison.

HIVE-BEES (*Apis mellifica*).

No. 1.—THE DRONE-BEE, or male, has a great spread of wing, fine eyes, and a spacious abdomen, but he has no apparatus for collecting pollen and no sting. No. 2.—THE QUEEN has a long abdomen containing the ovaries, which can sometimes produce over a thousand eggs in a day. She has no apparatus for collecting pollen and her tongue is too short to reach the nectaries of most flowers. No. 3.—THE WORKERS do not usually produce eggs, but they do all the collecting of nectar and pollen.

workers. But it cannot be said that they are sluggards. Inside the hive is the third kind of bee, the queen, the mother of the workers and the drones. A peep inside would show the queen passing over the combs and laying an egg in every empty cell. This is the whole of her work, but she does it almost continuously for many weeks at a time, and new generations of her offspring are continually emerging.

The indoor work is divided among other workers. Some guide the queen in her progress and give her food; some are busy in the nurseries, feeding the young bees; others are making wax, or building new combs. There are cleaners and repairers; honey-brewers and store-keepers; and there are guard-bees that keep watch day and night in this well-ordered city.

A Swarm of Bees.

One can hardly call "swarming" a natural phenomenon, for the hive-bee is a semi-domesticated animal—the subject of man's breeding experiments and subservient to his control in many ways. But it is a very striking phenomenon in the life of the country during the early summer, and its human interest is not lessened when it is accompanied by the more or less superstitious custom of ringing bells and beating kettles. The old-fashioned method was to rattle the door-key against a frying pan, and its object was to induce the swarm to settle in a convenient place from which it could be collected by the owner, who has the right to follow his errant property even into his neighbour's garden. But it is far from certain that "tanging" has any efficacy at all; there are some entomologists, indeed, who would deny that the excited bees have any sense of hearing.

What does a swarm mean? In a general way "swarming" may be described as a migration from a well-peopled hive; but it would be too simple to say that it is merely the outcome of overcrowding. It is commonest in early summer, and usually takes place on a fine forenoon. The queen, instead of laying eggs as usual, moves restlessly about over the comb, and she infects the workers with her own uneasiness. They become feverishly excited and rush out of the doorway as if in a panic. The queen follows her children, and they will not settle unless she is with them. If they lose her—for, being weighted with eggs, she is apt to fall to the ground—the swarming bees will not settle. They may return

to the hive in a short time, and they may repeat the experiment soon afterwards with a young queen as leader.

The normal outcome of the swarming is a new community, and if the bee-keeper does not recapture the excited throng, the result may be that a settlement is made in a hollow tree or in some other place which is suitable for the bees, though not for their owner. In some parts of the country there are many communities of honey-bees that have become wild or "feral." Swarming bees sometimes find very suitable places, but it is highly improbable that they send out scouts to discover good lodgings. Enthusiasts have a tendency to forget the extreme unsuitability of many of the places in which the swarmers sometimes settle down—being compelled to settle by the simple fact that the queen cannot fly any farther.

The swarming bees pour forth like a torrent, and whirl in the air like a dust cyclone. They are not usually out of temper, for they take a good meal before they start, but they are beyond doubt greatly excited. They may be thousands strong, and they make a characteristic noise which sounds gladsome to generous ears. Part of the buzzing is simply due to the very rapid vibration of the wings; but there is another sound that is produced by the rapid passage of out-breathed air from the narrowed openings of the air-tubes.

The sense of smell is raised to the *n*th power in hive-bees, and it is probably by the absence of a certain fragrance that they become aware that they have lost their queen. If she is with them, all is well; and they cluster in a dense mass, like a scrimmage in football, but multiplied a hundred times. They hang together on a branch in a close-packed crowd, forming a mass sometimes as big as one's head, and the bee-keeper who knows his business has rarely much difficulty in transferring them to a cool, clean hive. That indeed is just what they want. What puzzles the naturalist is the *concerted action* amid the excitement, for we cannot any longer think of them in the old way, which read the man into the bee:

> "Swift as the falcon's sweep, the monarch bends
> Her flight abrupt: the following host descends
> Round the fine twigs, like clustered grapes they close
> In thickening wreaths, and court a short repose."

Photos: G. H. Hewison.

1. QUEEN CELL, WITH THE LARVA FULLY DEVELOPED.
2. QUEEN-PUPA IN ITS CELL.
3. QUEEN CELL, AFTER EXIT OF THE QUEEN.

While the other cells in the comb have their mouth sideways, those in which the queen bees develop always hang with their mouth downwards. Out of the egg comes a grub or larva, which changes when full grown into a pupa, and this by metamorphosis gives rise to the fully formed queen.

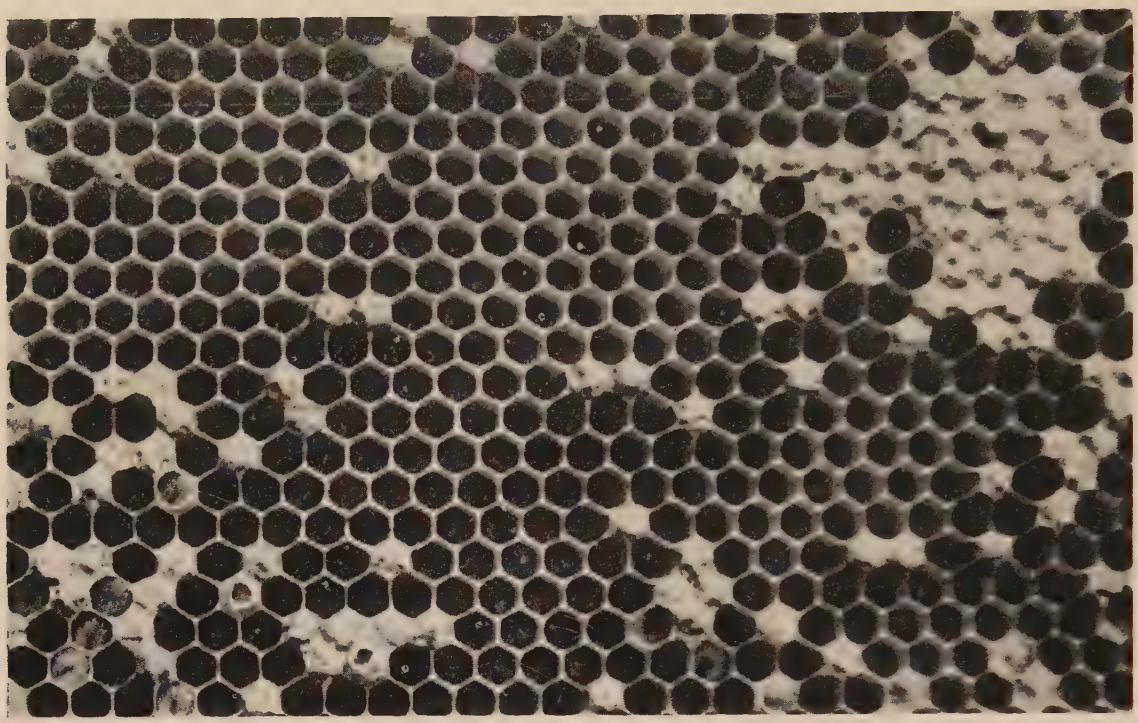


Photo : G. H. Hewison.

BROOD-COMB OF HIVE-BEE, WITH CELLS CONTAINING WORKER-GRUBS.

Photo : Underwood Press Service.

COMB SHOWING DRONE, WORKER AND HONEY CELLS.

The cells in which worker-bees are reared are the smallest ; those in which drones develop are larger ; those for queens are much larger, and of these there are not usually more than half a dozen or so in a hive. Honey-cells or store-cells are of the same size as those in which drones develop. The sheets of comb hang vertically ; the cells are not quite horizontal, but have a slight upward tilt. When a cell is nearly full, it is sealed with a cap.

What we have spoken of is a normal primary swarm which relieves the pressure of population in the old hive and leads to the starting of a new community. But a swarm may be prompted by other conditions besides overcrowding and lack of empty combs for egg-laying and honey-storing. It may be lack of sufficient ventilation in the hive, or an over-production of drones, or some other cause of discomfort that brings on the "swarming fever."

We must also distinguish the primary swarm led by the old queen, the mother of all her retinue of workers and drones, from a secondary swarm led by a young queen who has been developed (in about a week) in one of the royal cells of the old hive left queenless by the swarm. This young virgin queen becomes aware of her unhatched sisters within the royal cells, and utters a "piping" sound, interpreted by some as indicative of angry jealousy. If she is allowed, she will tear open the cradles and sting her younger sisters as long as her strength lasts. But the workers do not usually allow such extreme measures. The young virgin queen may lead off a secondary swarm a day or two after the piping, or she may not leave the hive till she flies forth on her nuptial flight, whence she returns fertilised and maternal, never to come out again unless she leads off a primary swarm. We must not leave this familiar story which never loses its strangeness, without noticing that it is the bee-keeper's business to *prevent* "natural" swarming, which is apt to be wasteful, by methods of control that are always becoming more subtle as the fine art of bee-keeping calls science to its aid.

The bee-community is at the height of its prosperity in summer; active, industrious, harmonious. The other seasons have their varied pictures to show. Autumn is a time of distress. The air grows chilly, and flowers grow scarce, and tired bees leave the hive and make no return journey. The ranks are thinned. Then it is that robber-bees try to plunder the honey-stores. Then, too, is the time of the tragedy of the drones, for one day the workers turn on the drones, who will feed though they do not work, and kill them all.

The Year round in the Hive.

Winter comes, and work ceases. The bees that remain gather round the queen in a cluster, and thus they pass the cold months, not exactly sleeping, but with the fires of life burning very low. Honey from the store-cupboards is passed from one to another through the drowsy mass, and warmth is kept up by a gentle beat-beat of many little wings.

Early in the year, as soon as the first spring flowers are opening, there are stirrings in the bee-hive. Those workers which have survived

Photo: G. H. Hewison.

SWARM OF ITALIAN LIGURIAN BEES ON AN APPLE-TREE.

Swarming is an overflow of the bee population from a prosperous and well-filled hive. It is said to be preceded by scouts, who search for a suitable place for a new home; and a swarm is typically accompanied by an unmated young queen.

Photo: John J. Ward, F.E.S.

NEST OF STONE HUMBLE BEES (*Bombus lapidarius*).

The soft covering is removed from the surface to show the comb and cells. Two cells are broken at top to show the white, fat bee grubs. This common humble-bee, marked by a red patch at the tail-end of the dark body, often makes its nest under a stone.

the trial of the cold weather, start "spring-cleaning," and building new combs. Some sally forth for water and food. The queen-bee rouses herself, and starts to re-fill the endless rows of waiting cradles.

Some of the workers, as we have seen, are able to survive the winter, kept alive by the supplies of food they, or their older sisters, gathered so industriously in the summer months, and so their community is more or less permanent. This is not the case with humble-bees or with wasps. Their colonies break up in the autumn; only the future mothers survive the winter. They rest in holes through the cold season, and when spring comes they start afresh, and found new colonies.

The Bee Language.

It is well known that bees have a very keen sense of smell, and that they find out certain things, such as the presence or absence of the queen, by this sense. It is also known that they express their feelings by changing their "hum" or "buzz." But we owe to the careful experiments of Professor Frisch a somewhat unexpected disclosure of a "bee language." It is a strange story.

When an exploring bee discovers some flowers affording an abundant supply of nectar, the first thing it does is to take as much as it can hold. Then it returns to the hive, and in a short time some of its comrades appear on the scene. More and more come and go till there are as many bees as the flowers can supply. When the economic ratio is reached, no more new bees come out from the hive. It looks as if the bees recognised that it is unprofitable for their demand to exceed the supply.

These observed facts raise two questions. How is it that the bees "know" when to stop adding to the numbers of collectors who visit the particular patch of flowers? And how do the discoverers of the new feast of honey make their fellow-workers aware of it, and in such a precise way that they rediscover the patch? Frisch experimented with marked bees, and definitely located feasts of honey and similar food: he was also able to observe what happened when the bees—variously successful—returned to the hive. He has given reasonable answers to the two questions.

When a bee that has sucked to the full returns to the hive, it executes a "round dance" on the comb. This excites the workers resting in the

immediate vicinity, and they hurry out to win a similar success for themselves. But when a bee comes home with a very small supply of nectar, it does not dance, and no " new bees " issue forth. Thus it is the dance that tells the hive when a promising source of supply has been discovered !

But how do the new bees find the treasure ? Experiments do not confirm the old theory that the discoverer accompanies its neighbours and leads them to the spot. The new bees hurry off by themselves, and begin an energetic scrutiny of the neighbourhood, to a distance, it may be, of half a mile. But though they search diligently, it is not at random. They have a clue, and that clue is a scent. The discoverer, as we may call her, brought home to the hive not only nectar, but a fragrance ; and as she danced on the comb her neighbours touched her, and thus got a definite impression of the characteristic fragrance of the promiseful flowers. It is for hints of that fragrance that the new explorers search as they fly eagerly hither and thither.

But what of the rediscovery of flowers that have no fragrance, though plenty of nectar ? It may be that in such cases, the new explorers pay no attention to scented flowers ; they are aware that it was not from any one of these that their successful sister obtained her abundant meal. But there is another and a better answer. Bees have on their posterior body a protrusible glandular pocket, which produces a characteristic scent, perceptible even by man and at once recognisable by bees. When the discoverers are feeding eagerly at the nectariferous flowers they protrude their scent-organ, and thus spray the blossoms—whether fragrant or not—with the tell-tale odour. This serves as a clue to the new explorers. The two clues taken together work exceedingly well, as well as, or better than, if the discoverer led her sisters to the very spot. Thus if they follow the floral scent carried by the discoverer, they have some chance of finding other patches of the same species of plant, and thus tapping fresh supplies.

It must often happen that a group of flowers is damaged by bad weather, and then the bee-visits become few and far between. But if the weather changes again for the better, and the flowers pick up again, the good news will soon be told in the hive by a dancing bee. And if there are workers resting on the comb who had previously visited the flowers, they will not lose much time in setting forth again.

What is true of the bees when they are bringing home nectar holds good for those that are collecting pollen. But the " language " will be, as it were, more emphatic when there is a heavy load of fragrant pollen in the so-called " baskets " on the last pair of legs. It is also interesting to find that the dance is different in the two cases. For half a minute or so the nectar-carrying dancer trips in a narrow circle, perhaps a dozen times, perhaps twenty ; not always in the same direction. But the pollen-carrying dancer sways her body gracefully and rapidly, first in a semicircle to the right and then in a semicircle to the left, the axis of the swing being immediately in front of the insect's head. There may be four to twelve swayings, and then a rest. The spectacle has a very exciting influence on the bystanders ; they come pressing in like sniffing dogs. They are eager for news.

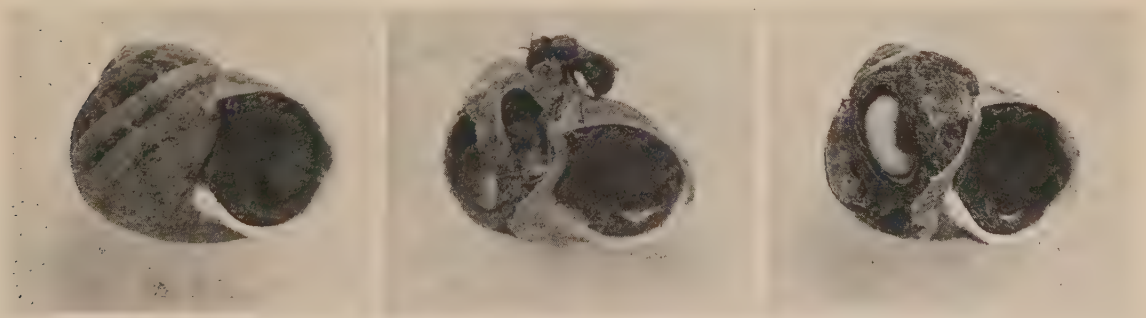


Photo : Hugh Main.

NEST OF A SOLITARY BEE (*Osmia aurulenta*) IN SHELL OF GARDEN SNAIL (*Helix aspersa*).

The solitary bees of the genus Osmia mostly utilise already existing cavities, in this case the empty shell of a snail. The centre figure shows a young bee just hatched out from the pupa stage ; the right figure, a shell broken into, shows a grub or larva. There are often just two larvæ in a shell, and Fabre found that one becomes a male and the other a female bee.

Photo: John J. Ward, F.E.S.

THE LEAF-CUTTING BEE (Megachile).

The solitary leaf-cutting bee, which is about the size of a hive-bee, uses leaves in the making of its cells. Here it is seen at work, the upper leaf to the right of the picture showing two neat curves, from which segments of leaf have been cut off. The bee has a cut-off piece of leaf hidden beneath its body.

Photo: John J. Ward, F.E.S.

CARRYING A PIECE OF ROSE-LEAF TO THE CELLS.

The cells are dexterously constructed of segments of leaf, curved on themselves, and a lid is made of smaller pieces.

We have lingered over Frisch's observations and experiments because they correct older views that were too generous, e.g., in supposing that the discoverer-bee led her sisters to the feast of honey. At the same time they disclose an intricacy of behaviour, marvellous even when analysed.

Another example of an insect society—in which each member performs certain work for the good of the whole community—is to be found in the ant-hill. Life in an ant's nest has much in common with that in a bee-hive. There are three classes, queens, drones, and workers, each necessary in its own way to the welfare of the community. Work is divided, and each worker must take its share, or, if need be, sacrifice itself for the common weal.

Life in an Ant-hill.

The queen is concerned only with egg-laying, while the workers undertake the duties of foraging, housekeeping, and nursing. When one turns over a big flat stone one often sees ants scurrying away, carrying with them little white objects. These are the young ants in their resting stage, inside the white cocoons they themselves have spun. The ant-nurses carry them to safety, just as, within the nest, they often move them from room to room to secure the proper degree of warmth. When the young ants are ready to come forth as perfect insects, the workers bite open the cocoons.

The foraging ants make a network of roads round the nest as they come and go. They can be seen returning to the home with their loads, and if one of them finds some prize, a caterpillar perhaps, that is too big for her to tackle alone, she will summon her companions to her aid, and together they will try all sorts of ways of dealing with the bulky booty, until they succeed in bringing it in to the nest.

One of the conventions of the ant-community is that if a

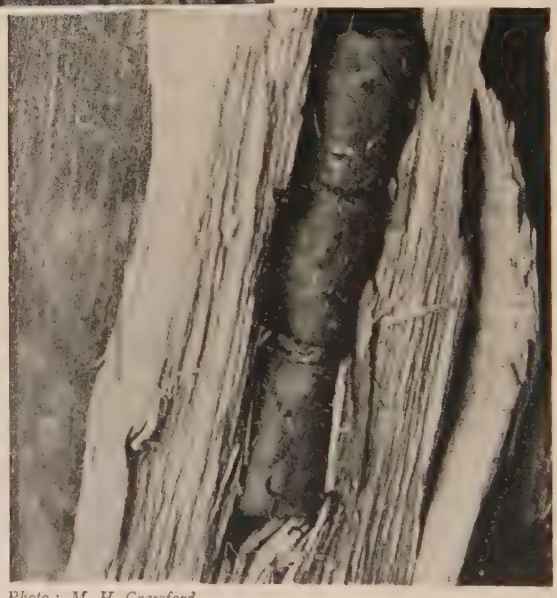


Photo: M. H. Crawford.

THE CELLS COMPLETED.

The nests are made in holes and the cells are often arranged end to end, as the photograph shows. They are triumphs of instinctive art. Each is half-filled with pollen and contains a single egg.

Photo: M. H. Crawford.

WOOD-BORING BEE, HANGING BY ITS JAWS IN A QUIESCENT STATE.

This wood-boring or carpenter bee, Xylocopa, spends the winter as an adult, in a state of suspended animation, but it habitually seeks out a sheltered nook. One of the Eastern carpenters has a special cavity on its posterior body where minute mites are given hospitality.

Photo : M. H. Crawford.

CELLS OF WOOD-BORING BEE.

The broad cells made by this powerful bee, Xylocopa, are built of cut-off fragments of wood glued together with saliva.

Photo : M. H. Crawford.

WOOD-BORING BEE, EMERGING FROM A CELL.

The cells in which development takes place are usually in galleries connected with a main shaft drilled in dry timber. Those in the lower photograph have been separated off from their natural position. The carpenter, as it is often called, is a dark-coloured, hairy, solitary bee, of great muscular strength.

hungry ant applies to a full ant for food, it must be fed. It is said that if an ant refuses to disgorge a drop of food for another it may be put to death by the other workers !

Guests and Pets.

The ants have many peaceful occupations. They build and they tunnel ; some of them cultivate plants and gather their seeds, while others grow a palatable fungus which they enjoy very much, on specially prepared beds. One of their strange habits is that of keeping pets. A number of other insects are often found in the ant-hill, some of which are merely tolerated visitors, while others are apparently welcome guests. Little crickets find food and shelter there—if they beg in vain for food, they will steal it instead. Beetles, too, are often fed by the ants, which yield to the beetles' persuasive caresses by sharing with them the sweet substances they carry in their crops. These beetles have a fragrant scent, which the ants seem to like ; but some ants carry tiny mites about on their bodies, and feed them, without so far as we know, getting anything in return. The only explanation of their care for them is that they are fond of their pets !

Photo : T. Dobson F.E.S.

MASON BEES, SHOWING TWO CELLS AND TWO BEES.

The solitary mason-bees, of the genus Chalicodoma, make very solid nests of earth mixed with the salivary juice. This is used as the mortar in which carefully selected pebbles are embedded. The cell is then half-filled with a mixture of pollen and honey, and after an egg has been laid the mouth is closed up with cement.

Other little insects found in the nest are " domesticated animals " rather than pets. The aphides, or plant lice, so common on our rose-bushes, secrete a sweet fluid, of which the ants are very fond. For the sake of this " honey-dew " the ants cherish and feed the aphides. They stroke them with their feelers, and lick the sweet juice that oozes from their bodies. They even go as far as to collect and care for the eggs of the aphides, sheltering them through the winter, so that they may keep up their supply of " cattle." Some of them make little " cattle-pens " of earth, where they keep the aphides, all ready to be " milked " of their honey-dew.

Some kinds of ants have different types of workers, for example, one species has workers which have taken upon themselves the rôle of " honey-pots " for the community. In the nest there are grotto-like chambers, in which these individuals hang from the roof. These ants live in dry hot parts of North America, and they collect a sweet juice that is found for a short part of the year on the surface of a common variety of gall. When they return to the nest laden with this " honey," they pour it into the bodies of their passive comrades, till the " honey-pots' " crops are so full that the whole abdomen becomes round and swollen, with its covering plates far apart. " When the yellow colour of the honey shines through the thin stretched skin of the spaces between the plates these singular creatures look almost like Japanese lanterns hanging from a domed roof."

Inside the nest harmony seems to reign ; no insects seem better to have learnt how to live together in a mutually helpful way.

Ants as Warriors.

But the battles of ants are also famous. They are seldom aggressive

when alone, but they have the instinct of acting together, and often carry out well-organised war-like expeditions. The ants of two different species sometimes become mixed up in an ill-natured turmoil, confusion seems to be the order of the day, yet every ant seems able to recognise those of its own band.

Many plants shelter ants in little holes and crevices. Sometimes the guests pay their way by keeping the plant free from destructive fungi. When a band of leaf-cutting ants comes to an ant-protected plant, the resident ants rush out to ward off their attacks, and fight the invaders vigorously until very often they are forced to beat a retreat.

Some of the workers among the leaf-cutting ants are "soldiers," large, round-headed and one-eyed, with specially strong jaws, well-suited for doing battle. Their grip is so firm and unrelaxing that the Indians are said to use them for stitching wounds. They let the soldiers bite the edges of skin together, then snip off the bodies. Even death does not unclench the powerful jaws.

Photo: Hugh Main.

PUPÆ OF BLACK ANT (*Lasius niger*) REMOVED FROM THEIR COCOONS.

This is a common garden ant in Britain, one of those species that are accustomed to utilise green-flies or Aphids for the sake of their honey-dew. The eggs of the Aphids are taken in autumn into the recesses of the extensive burrows that the black ant makes in the ground, and are carefully attended to. Some kinds of ants have practically naked pupæ; in this case the cocoon made by the larvæ has been removed. The uppermost figure is a side view, the lower left-hand figure shows the back, the other the central surface.

A distinguished observer, Mr. Beebe, has described the habits of the Army Ants, which make a structure of their living bodies, linked together, with countless jaws always in readiness to defend the colony. Mr. Beebe, at the cost of some fiery stings, spent many hours watching the life of the colony. The entrance of the structure was guarded by a mat of ants, which made a living archway through which others had to pass. When the soldiers returned with a load, they handed over their booty, and then submitted to being thoroughly scraped and cleaned by a group of workers. The colony was broken up by spraying it with formol. The ants unlinked themselves and moved off, carrying their young ones with them. Some remained near by for a day or so, tending those of the young which were passing into the pupa stage. They were seen gnawing wood into shreds to make a light covering for the young, which then began to spin cocoons. After a short time they all disappeared.

Ants and their Slaves.

Sometimes the expeditions of the ants take the form of a raid on the nest of some smaller species of ant, for the purpose of capturing slaves.

The prisoners are always babies and children, which are carried back to their captor's nest. After a little they emerge as workers and share the work of the colony.

Different kinds of ants show different relations with their slaves. In some cases the masters can manage quite well by themselves if need be, though they usually keep slaves to share their labours; but in other cases there is a price to pay for stealing their neighbours' children. The ants become so dependent on their slaves that they forget how to fend for themselves, and if their helpers refused to feed them they would die of starvation.

The Amazon ants cannot live without slaves. They seem to have lost every peaceful accomplishment. They cannot dig or tunnel; they cannot tend the young; they cannot even forage for their own food. They are soldiers, and soldiers only. Their jaws are suited for killing, and not for ordinary toil. When they are at home in the nest they pass the time cleaning and polishing their shining brown bodies, or begging

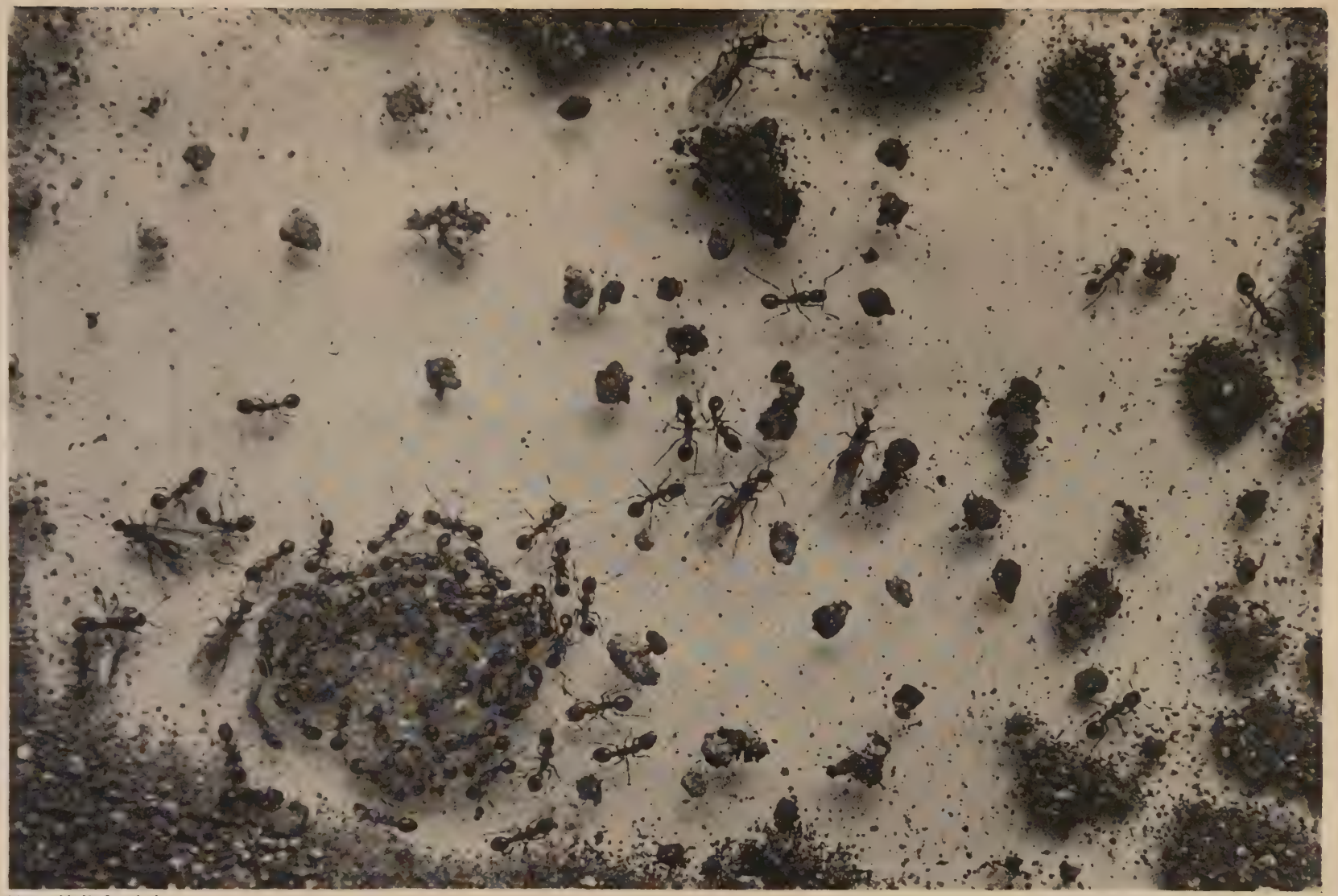


Photo: M. H. Crawford.

PART OF A COLONY OF SMALL GARDEN ANTS SHOWING PUPÆ, WORKERS, AND WINGED ANTS.

The winged ants are the males and females, and the wings are used only in the nuptial flight when the pairing takes place. Thereafter the males die, but the females settle down, shed their wings and become the mothers of a large family. The workers are imperfect females.

Photo: E. J. Bedford.

NEST OF WOOD ANT, THREE FEET IN HEIGHT.

This nest of *Formica rufa*, a common wood-ant, is built of pine needles and pieces of stick, and is often over two feet high. There is a record of one forty feet in circumference. There are innumerable rooms and passages in the dome itself and in the ground beneath, and of course there are many thousands of inhabitants. The numerous entrances into the dome are closed at sunset, perhaps to keep out small intruders.

for food. Their slaves seem to be willing helpers, ever ready to put food into their mouths. A life of ease, indeed; but what a contrast when the Amazons go forth to battle! Then they are intrepid warriors, resolute, courageous and precise. They have an extraordinary gift for combined action, which makes their raids very successful.

Experiments made by Professor Emery showed how instinct had its way. He put an Amazon queen into a colony of Brown ants. She immediately killed the Brown queen, and took her place, and in course of time there was a mixed colony, consisting of Amazons, which had never been outside the nest, and a number of Brown ants, which acted as slaves. They waited on the Amazons, but they also kept them indoors as long as they could. After a time, however, the Amazons became more and more restless, and finally some of them escaped and set out to explore. One scout found a nest of Brown ants, and promptly raided it, returning home with a captive—a cocoon, a new slave in its infancy.

Later on, after scouting had gone on for some time, an organised raid took place. Sixty Amazon ants made a sortie, and attacked a neighbouring colony of Brown ants. They did not give up their raiding expeditions until they had carried off 450 prisoners. On another occasion, the raiders kidnapped over a thousand slaves in less than two hours. One cannot quite admire the habit of capturing children and making slaves of them, but there is no denying that the Amazon ants do it very successfully.

Animal Architecture

Many animals show great architectural skill. Some build "homes without hands" and ramparts for defence; others make cradles for the young; others construct store-chambers for food; and various purposes may be served by the same building. The Bower-Birds build bowers for their amusement. Some Caddis-worms fashion beautiful traps for catching small water animals, and the spider's web might also be included under architecture.

Very common in warm countries are the hills of the termites or white ants, which illustrate very well what we mean by animal architecture. They are dwellings for large families or communities, and they sometimes contain several thousand inhabitants. The insects themselves are nearer to dragon-flies than to true ants; indeed termites and true ants are as different as different could be, except that both are social. The termite

The Termitary.

community includes a royal pair, the female or queen and the male, the great body of workers, a large number of soldiers, and also reserve males and females, which are kept in readiness to replace the reigning pair if any accident should occur. A common length for a worker termite is half an inch.

The termitary is usually made of earth and wood. Sometimes the earth has passed through the insect's food canal, sometimes it is simply chewed and mixed with fluid. It often becomes as hard as stone. The wood is also chewed and cemented. In many parts of South Africa the termite-hills are as thick as molehills on a badly infested field; they are often a yard in height and strong enough to bear a man's weight. In the wilder parts they are often much higher.

The greatest building achievements among termites are the erections made by the so-called "compass ants" or "meridian ants" of Australia. They are often ten feet high, and occasionally double that, triangular or wedge-like in cross-section. But the most remarkable feature is that they all point the same way, the long faces running north and south, the triangular gable ends turned to the east and west.

A mound sixteen feet in height may be built by termite-workers a fifth of an inch in length. Professor Houssay points out that the Eiffel Tower was 187 times the average height of the workmen who built it, but the termitary may be 1,000 times the height of the worker termite. To equal the termitary in proportion, the Eiffel Tower (1,000 feet high) would have to reach a height of over 5,000 feet.

But the details of the termites' buildings are as interesting as their dimensions. In the case of the Warrior Termite (*Termes bellicosus*), described by Houssay, the dome-shaped dwelling may be ten feet high and its walls may have a thickness of two feet at the base. A huntsman sometimes climbs to the top to get a good view all round.

Photo: John J. Ward, F.E.S.

WINGED QUEEN ANTS, EMERGING FROM THEIR PUPAL ENVELOPES.

There are four chapters in the life-history of an ant: (1) The developing egg, (2) the grub or larva, (3) the quiescent pupa (sometimes in a cocoon made by the larva, sometimes naked), and (4) the fully formed insect, whether winged as in the males or females, or wingless as in the workers.

There are passages running through the walls, giving entrance to the various levels, and there are staircases winding up to the summit. The former are used every day and every night for going out and coming in; the latter were

Photo: Reginald A. Malby.

A CLUSTER OF ANTS' EGGS.

What are called "ants' eggs," and used as food for cage-birds, are the pupæ, the third chapter in the life-history of the ant. Inside the pupa a remarkable transformation occurs, for the structure of the grub is changed into that of the fully formed insect.

used by the builders in carrying earth. In the ground below the termitary there are holes, like quarries, from which the earth was dug. They may afterwards serve as cellars and as catacombs.

On the ground floor there is the royal chamber, where the bloated queen lays eggs at a great rate. Round this are rooms for the attendant workers and the bodyguard of soldiers. Farther away there are store-chambers with particles of vegetable gum and other reserves.

The first floor is a spacious hall supported by earthen pillars, which may be a yard high. The second floor is a great nursery, where the young termites are reared in little pigeon-holes made of chewed wood. The walls of the nursery are covered with a glistening fungus, which is used as food. The top storey is a well-ventilated empty attic. Plainly, it is a well-designed house.

In Jamaica and some other countries there are termite "nests" fixed on trees, and connected by a gallery with the main dwelling underground, and by other earthen tunnels leading to the top of the tree—for termites have a deeply rooted objection to facing the light of day. This kind of erection, made of very minute wood particles glued together with saliva, varies in size from a man's fist to a hogshead, and may be described as an "annex." There is a firm outer wall and many compartments in the interior. It is *a hanging house*, and from it we may pass to the wasp's nest.

A Wasp's Nest.

Some wasps always build underground, as is the case with *Vespa vulgaris* and *Vespa rufa*; others build always in the air, hanging their nest to a branch or inside a hollow tree, as in the case of *Vespa norvegica*; others, like *Vespa sylvestris*, try both situations. But we shall keep to the familiar hanging house, which may vary in size from a Tangerine orange to a bandbox.

The house is made of a kind of paper or wood-pulp, and the wasps plane off the material from posts and palings and bare tree stems. A central support is fastened to a branch, and on it there is hung the first storey, which carries a number of cells or cradles on its down-turned surface. From the middle of this, the central support is continued downwards and bears the second storey. Below this a third is built, and so on. Besides the central support fixing storey to storey, there are extra beams, also running vertically from one level to another. Then over the whole series of stories there are numerous —sometimes over a dozen—umbrella-shaped overlapping envelopes of the same papery material, waterproof and wind-proof, and all very light. The temperature within may rise to 30° F. above that of the surrounding air. An entrance is left open at the foot. It is plain that there are some good ideas in the wasp's nest—a paper house, a hanging house, a house of many storeys, a house well sheltered from rain and wind!

Photo: John J. Ward, F.E.S.

ANT SHEPHERDING GREEN-FLIES ON BRANCH OF GOOSEBERRY BUSH.

Some kinds of ants use the green-flies or Aphides as cattle, stroking them with their feelers so that they exude more honey-dew, which the ants lick up with great gusto. The ants may also take charge of the Aphides' eggs for the winter.

Photo : Paul Griswold Howes, Bruce Museum, Connecticut, U.S.A.

CARPENTER ANTS AT WORK (much magnified).

The ant to the left, occupying the entrance to the nest in the timber, is handing a chip of wood to the " porter " on the right, who will proceed to carry it away. The timber is often honeycombed with passages.

There are some details that are of great interest. Thus as one storey or comb is added after another—seven is a common number—and as the cells come to contain grubs, the weight is greatly increased, and there is a strengthening of the original support up at the top. Only the beginning of the edifice is the work of the mother-wasp or queen, for after she has made the original fixture and part of the first comb and several umbrella-like envelopes, she has worker offspring ready to do their part, and to them all the rest of the building is due. As the comb is broadened out by adding new cells round the margin, the innermost envelope is cut away and a new outermost one is put on. This is always going on. In adding wood-pulp to an envelope to increase its size the wasp stands on what has been already made and retreats along the margin so that it does not step on the soft material.

As to the population, it may be noted that in the underground nest of *Vespa germanica*, the French naturalist, Charles Janet, counted 11,500 cells on seven combs. Over 11,000 had been used twice and about 5,000 thrice. In his valuable book on " Common Animals " (1904), Mr. Oswald H. Latter calculates that a large nest of ten or eleven combs might have a population of 50,000 or 60,000 wasps. But of all the multitude only the young queens survive the winter. That is the tragedy of the hanging house !

Architecture among Ants.

There is little among ants to compare with the hanging house that wasps make or the great tower that termites build, but there are some interesting achievements at a lower level. The ants' nest is often a mine excavated in the earth by a multitude of jaws. The entrance to the shaft is sometimes surmounted by a turret or a dome, which helps to keep the underground dwelling warmer. There is an extraordinary Indian nest, where the vase-

Photo: T. Dobson, F.E.S.

SMALL NEST OF A TREE WASP WITH THE LOWER PORTION REMOVED TO SHOW THE COMB.

One storey or comb is hung on to another by vertical beams or pillars. The cells are closed above and open below but after the egg, which is fastened to the roof, develops and hatches, the grub spins a cocoon and closes the down-turned mouth of the cell with a tough silken floor, which projects like a dome.

like turret is surrounded by six to eight circular ramparts, the outermost nearly a foot in diameter.

The underground dwelling is often more like a city than a house. Thus Professor Forel studied one in Algiers, which had half a dozen openings, like the craters of volcanoes in shape, at intervals of three to ten yards, and all connected by an underground passage, running at a depth of about five feet. He estimated that the whole excavation must have extended over fifty to a hundred square yards. Corresponding to each "crater" there was an underground granary, but it was all one vast nest, inhabited by a single community. The grains of sand are carried out in the jaws or entangled among special hairs about the mouth.

Many ants with underground nests may be found sheltering under bark or in decaying stumps that are dry. They may make galleries and chambers out of the wood-dust. Sometimes they have arboreal stables in which they keep their "cows"—the Aphides. When the autumn comes the cows' calves are often taken underground for the winter, and the eggs they lay are cared for by the ants.

But there are special tree-ants which make elaborate tunnels. There is a little doorway in the bark, a straight passage through the sapwood, which they do not injure, and then a maze of passages, up and down and crossways. The tunnels may be so numerous that the tree gives way in a storm, and the same thing may happen to the wooden support of a bridge or of a hut. Of course these tree-boring true ants must not be mixed up with the termites.

Some ants make papery nests of wood-dust, cemented with the juice of the mouth, and sometimes eked out with fibres and the like. Inside the nest there is often a velvety growth of a black mould which the ants are fond of eating. Paper nests are usually about six inches long, but they may reach two feet, and Forel describes big ones in the Brazilian forests that hang down like stalactites in a cave, or, when they are covered with drooping threads, like the beard of some great giant among the trees.

The well-known tailor-ants of warm countries unite in small companies to draw leaves together, but the problem is how to fix them, for the full-grown ants have nothing that will serve as glue. While some of the workers hold the leaves close together, others fetch the young ones which have a sticky secretion in their mouth. A worker-ant holds a grub in its jaws and dabs it against the leaf, as if it were a gum-bottle. The fine sticky thread from the mouth of the larva fixes the leaves together. This is a unique case, the young ones aiding passively in the labours of the adults. So much for architecture among ants!

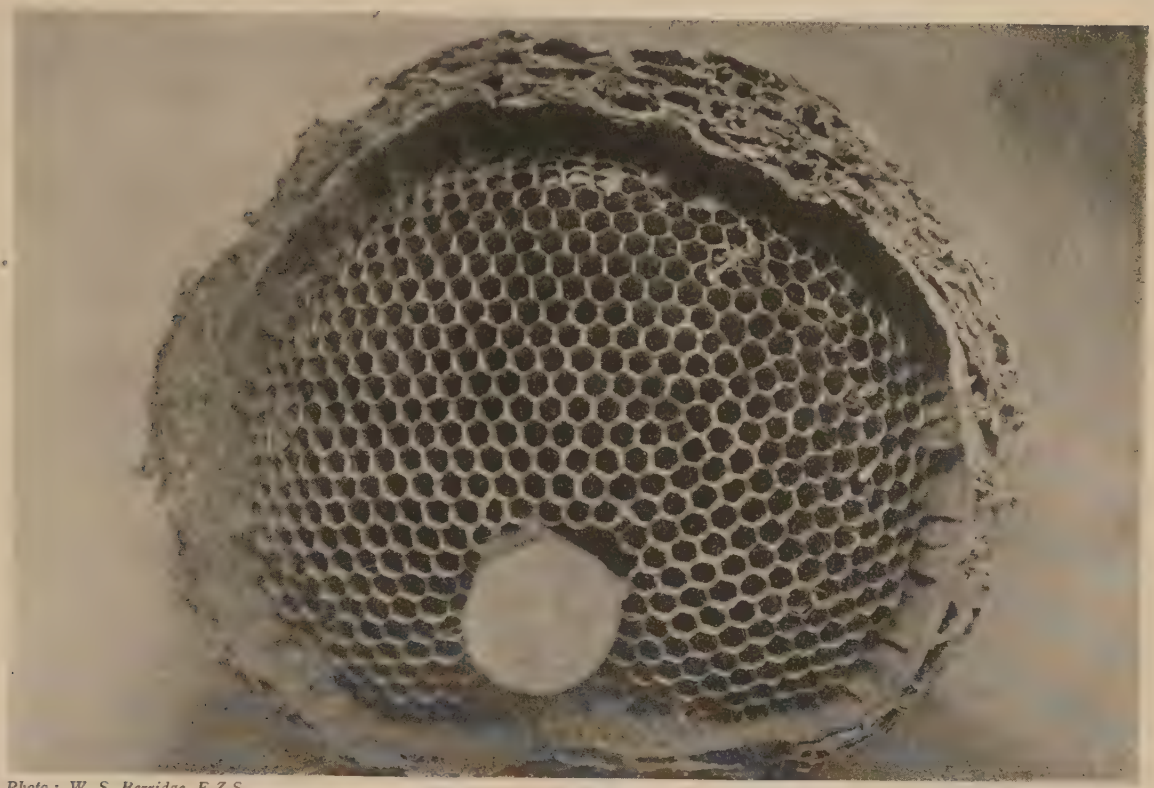


Photo : W. S. Berridge, F.Z.S.

SECTION THROUGH NEST OF WASP (*Montezumia dimedeata*), FROM BRAZIL, ATTACHED TO BRANCH OF TREE.

The photograph shows the many-layered outer envelopes of the nest, water-proof and wind-proof ; and inside this a storey of hexagonal cells, in which the eggs develop into grubs, and the grubs into pupæ, and the pupæ into winged wasps. The white circle at the bottom of the nest is the branch cut through.

Photo : T. Dobson, F.E.S.

NEST OF THE BUILDER WASP (*Odynerus parietum*).

The builder wasp makes its nest of mud in the crevices of walls. Often the nest has the rough appearance of a splash of mud which helps it to escape detection by the wasp's enemies ; yet it is skilfully constructed to withstand the elements. Paralysed caterpillars are stored in the cells as food for the carnivorous grubs, and when stocked the cells are sealed up. The photograph shows two sealed cells stocked with grubs and their food. Another is not yet completed.

Photo: Leon Bayer, M.D., by courtesy of the New York "Zoological Society Bulletin."

MONSTER TOWER ERECTED BY WHITE ANTS IN EAST AFRICA.

The White Ants or Termites are not nearly related to the true ants, but they show resemblances in habits. Thus there is a similar division of labour in the colony, for besides queens and males, there are workers and soldiers. The tower in the photograph is made of chewed earth moistened with saliva, and includes an intricate architecture of rooms and corridors.

XXXVI
THE WORK OF EARTHWORMS

LITTLE heaps of finely powdered earth are a familiar sight on any lawn or meadow, a sign that underneath the grass many tunnellers are at work. In the daytime these tunnellers keep under ground so far as possible, but a visit to the lawn at night with a lantern would give an idea of their numbers. For it is at night that earthworms come out to feed. Many of them do not come right out and crawl about, but keep the ends of their bodies in the safe shelter of their burrows, ready to retire quickly if danger is near. The earthworm's body is made up of a great many rings, over two hundred sometimes, and can lengthen out to a surprising extent. So the worm often keeps the tail-end underground, and, stretching out its elastic body as much as it can, sweeps its head round and round in slow circles. The very sensitive tip of its body forms a rather pointed hood, beneath which is the mouth, and it seeks out leaves and other food materials and helps to drag them back into the tunnel.

The worm draws some leaves over the entrance of its burrow, partly to hide it, but also probably to keep it from becoming too dry, for earthworms, though they are not found in very wet places, require a good deal of moisture.

The Burrows.

The burrow runs down several feet into the ground, with its walls made hard and firm by a sticky substance that oozes from the worm's skin. At the end of the burrow there is a slightly enlarged space, and to this chamber the worm brings the leaves. It covers them with a digestive juice, which softens them and makes them suitable for food.

The earthworm is continually tunnelling through the soil. Its sensitive head-end feels the way, and its muscular body pushes the particles of earth aside. It knows when it is near the surface of the ground, for, though it has no eyes, the front part of its body is sensitive to light. It cannot hear the blackbird hopping across the lawn, for it has no ears, but it can feel even the slightest tremor of movement through the soil. In spite of its retiring ways it has many enemies—the birds are quick to snap up any belated wanderers in the early dawn; the active centipedes come prying into the

Photo: John J. Ward, F.E.S.

EARTHWORM COMMENCING TO BURROW.

There are many different kinds of earthworms, but the habits are very much the same in every case. In loose soil there is some burrowing of a simple kind, by forcing the particles to the side with the head. But in firmer soil the earthworm must eat its way, and in so doing it utilises the decaying vegetable matter in the soil as part of its food. The head end is more pointed; the tail end is flatter.

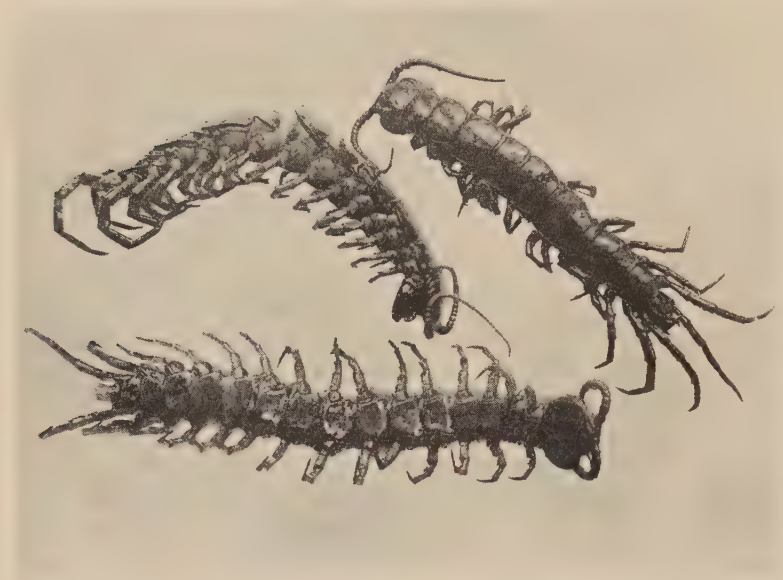


Photo: Harold Bastin.

EARTHWORM-HUNTING CENTIPEDES (Lithobius).

In contrast to the vegetarian and innocent millipedes, all centipedes are carnivorous and poisonous. A common British species is *Lithobius forficatus* which has fifteen rings, each with a pair of legs. It is an inveterate enemy of earthworms and often pursues them into their burrows.

burrows; and the mole, itself a tunneller, breaks into the underground chambers and preys upon the worms as they lie together in a clump on wintry days.

Sometimes the soil is too hard, or too root-bound, for the worm to push its way through. Then it makes its tunnel by eating through the ground, passing the soil through its body. It does this habitually to get food, as well as to make its burrows, but not so much when there are plenty of decaying leaves to be found. It takes the soil into its mouth, and it passes down the gullet into a little swollen sac, called the crop. Beyond the crop is the gizzard, which not only has hard, muscular walls but also often contains tiny stones. The gizzard is an effective mill. Here the soil is rubbed and crushed into a fine powder, which then passes down the remaining part of the food-canal. Particles of plants or animals are digested in this part, but the soil itself is of no use for food, so is thrown out at the end of the body. This fine soil, which has passed through the whole length of the worm and becomes mixed with digestive juices, forms the tiny heaps, or "worm-castings," seen near the mouths of the burrows.

The work of earthworms is of the greatest importance to man. The small amount of damage they do in nibbling the green corn or sampling the carrot-tops is insignificant, insect larvæ and slugs are responsible for far more of that, and, in any case, it is a small price to pay for the services of the worms. Not that they are intentionally helping mankind—they are simply leading their natural lives, and it so happens that their ways are of great benefit to us. They are by far the most important ploughers of the earth. It is true that there are larger animals, such as field-mice and moles, constantly tunnelling in our agricultural land. But the sum total of their burrowing does not begin to compare with the results of the work of the thousands of earthworms in every acre of the fields.

Soil-making.

It is to the careful and patient observations, experiments, and calculations of Darwin that we owe our knowledge of the part played by earthworms in making the earth fertile.

By their tunnelling the earthworms are continually loosening the soil. Air and raindrops can enter by the burrows, and plant-rootlets can find their way down to a depth where they secure the food-materials and moisture they

Photo: Hugh Main.

A CARNIVOROUS SLUG (*Testacella haliotidea*), THAT HUNTS EARTHWORMS IN THEIR BURROWS.

This interesting slug dislikes the light of day, but hunts for earthworms in the evening. It has great power of elongating its body and of disappearing into the earth. It can protrude its toothed pharynx in a remarkable way and harpoon an earthworm. The eggs, which are laid in the soil, are unusually large, about one-sixth of an inch in diameter, each enclosed in a tough envelope.

Photo: James's Press Agency.

EARTHWORMS, WITH THREE PILES OF CASTINGS.

Earthworms depend on the leaves and other parts of plants that they find in the soil, or drag down into their burrows. What they eat passes through the long food-canal, which has a pharynx, gullet, crop, gizzard, and digestive intestine; and the powdered mineral matter, which is of no use, is passed out at the posterior end, forming the familiar castings on the surface.

require. Plant growth is increased by the presence of leaf-mould. As we have seen, the worms bury leaves, and the digestive juice with which they cover them helps to change them into a rich mould, which makes the soil more fertile. After a time, discarded worm-burrows lose their firmness, crumble, and fall in. This causes movement in the earth, and exposes new parts to the action of the rain and air. Minute particles in the soil are set free by the bruising in the mill of the gizzard, which brings about a closer mingling of different elements. Worm-castings form a manure for the grass. In the course of time, the continual eating of soil and bringing the castings up to the mouths of the burrows means that the whole surface is gradually covered with a fresh layer of soil, rich, finely powdered soil, turned up by the little ploughers.

The work of the earthworms may be summed up in three words: burrowing, burying, bruising. It is not easy to realise how such small creatures can have such results as are claimed for them. Gilbert White wrote in 1777: "Earthworms, though in appearance a small and despicable link in the chain of Nature yet, if lost, would make a lamentable chasm . . . . Worms seem to be the great promoters of vegetation, which would proceed but lamely without them. . . . The earth without worms would soon become cold, hard-bound, and void of fermentation, and consequently sterile . . . " He pointed out in a general way the importance of the burrowing, burying, and bruising; but Darwin's exact observations show more fully how great results may be reached by adding together many small efforts.

Burrowing, Burying, Bruising.

Darwin made many experiments with earthworms which he kept in large flower-pots in his

study. He watched how they tackled their food, what kinds of plants they liked best, and how they dealt with different shapes of leaves, and what effect the digestive fluid which they secreted had on various kinds of leaves. He noticed when the worms were most active ; and how much soil passed through their bodies in a certain time, and so on. He checked these observations with others made by lantern-light out of doors.

He estimated that there are on an average 53,000 earthworms in an acre of garden ground, and about half that number in open fields. If we can realise such figures, we begin to understand the importance of the burrowing, burying, and bruising carried on by these thousands of worms.

To show how the surface of the earth is changed by the earthworms' work, other observations were made. Marked stones were watched, and the rate at which they sank into the ground was noted over periods of many years. Why does a big heavy stone sink down more slowly than a small thin one ? Earthworms dislike cold, and if a big stone is too thick for the sun's rays to penetrate, the ground underneath is cold, and no worms are found there. Under a flat stone they congregate because of the warmth, and make burrows there, which fall in after a time, so that the stone sinks.

Part of a field was covered over with lumps of chalk, and left untouched by man for thirty years. But the earthworms continued their work and at the end of the thirty years the layer of chalk was seven inches below the surface. A well-known example is the story of the "stony field," a very rough field, covered with hard flint stones. It also was abandoned for thirty years, after which, we are told, a horse could gallop from end to end of the field without striking his hoof against a single stone !

Worm-castings, from marked squares of land in different kinds of country, were collected daily for a year, and dried and weighed. The castings from one square yard for one year were found to weigh three-and-a-half pounds. The amount of earth brought up to the surface on an acre of similar ground in a year would be seven tons.

Another of Darwin's figures was that in garden ground fresh mould was brought up to the surface at the rate of three inches thickness in fifteen years. When we hear that his estimate of the amount of earth that passes every year through the bodies of the earthworms of England was 320,000,000 tons, we realise our dependence on worms for soil-making and soil-improving, and can imagine how poor the crops must be in those parts of the world where earthworms do not flourish. But they are found in almost every region of the globe, up to a height of about 10,000 feet. They do not, however, thrive in very hot climates, owing to the dryness ; or in very wet places, where they are apt to be drowned ; or near the salt spray of the sea.

Darwin's Work on Earthworms.

Many other observers have followed Darwin's example, and given us very striking figures concerning the effect of earthworms on the earth. For instance, in one very fertile and healthy district of West Africa worms are very abundant, and it was calculated that every particle of soil to the depth of two feet was brought up to the surface once in twenty-seven years, which means very effective natural ploughing.

Darwin's own summary shows how important a factor earthworms have been in the progress of the world : "When we behold a wide turf-covered expanse, we should remember that its smoothness on which so much of its beauty depends, is mainly due to all the inequalities having been slowly levelled by worms. It is a marvellous reflection that the whole of the superficial mould over any such area has passed and will again pass every few years through the bodies of worms. The plough is one of the most ancient and valuable of man's inventions : but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed by earthworms. *It may be doubted whether there are many other animals which have played such an important part in the history of the world as these lowly organised creatures.*"

XXXVII
HUMBLE ANIMALS OF THE SHORE

ONE of the best known of all our shore animals, and one which is found all along our coasts, is the common Shore Crab. Baby crabs, no bigger than a bean, scurry in hundreds over the sand and gravel, and formidable old warriors three or four inches across lurk under the stones or in the corners of the rock-pools. Everyone is familiar with the beady black eyes, the smooth-backed armour of green or black or brown, and the strong pincer-like claws : for the Shore crab attracts attention, not only because it is so common, but because it is lively and enterprising. The little world of the shore, when the tide is out and we are able to explore it, is at best only half awake ; but the crabs remain active and alert. We may happen to find one crawling about, or to see another squatting in a corner of a rock-pool, motionless except for a ceaseless, slight stirring of some of the little limbs that surround its mouth ; a rapid, fanning movement, which may set up quite a distinct current of water in the pool. On the whole, however, they prefer to be hidden, and it is under stones and seaweed that we must look for them : and if we succeed in driving one out on to an open patch of sand, it will try to run away,

Photo : F. W. Bond.

LARGE WHELK (*Buccinum undatum*), BEARING ON ITS SHELL TWO SEA-ANEMONES (*Sagartia parasitica*).

In this case the sea-anemones have the advantage of being carried about by the whelk, but their presence is probably immaterial to their bearer. But if the shell of the " buckie " were occupied by a hermit-crab, there would arise a mutually beneficial partnership.

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

OCTOPUS ATTACKING A CRAB.

The octopus grips the crab by two or more of its eight sucker-bearing arms and bites it with its parrot-like beak. The salivary juice from its mouth seems to bring about an almost instantaneous paralysis or poisoning of the victim, and the secretion is digestive as well.

always facing us, and always with its strange, sideways crawl, to the nearest shelter. But if we prevent this, and bend threateningly over the tiny creature, it will at once prepare to defend itself. Just as a man who has learnt boxing will spring back and raise his fists if he is attacked, so the crab throws itself into its own fighting position: crouching on its bent legs, it throws its great claws outwards and as widely apart as possible. If we still seem to threaten, it will suddenly clash the claws together, as though to show how strong and quick they are; while if we turn away for a moment, it will get off to some protecting boulder, or "dig itself in" by burrowing backwards into the sand till it is completely hidden.

It is natural to wish to compare the behaviour of the indomitable little crab with the courage of the dog or the cunning of the fox. In fact, however, it is impossible to make the comparison. Everyone knows that there are plucky dogs and timid dogs: one fox will rely on some particular trick for escaping from its pursuers, while another fox may act quite differently. Each fox learns its various devices for itself; but all crabs will behave in the self-same way. As we have already seen, behaviour of this kind, which is shared equally by all the members of the race of crabs, is called "Instinctive"; but the behaviour of the fox, when it finds a way of breaking into a hen-house, is Intelligent.

The smaller crabs have many enemies; when the tide is out they may be snapped up by the gulls, and when the tide is in they have most to fear from the conger-eels and other fishes. Even the larger and stronger crabs have their persecutors, and one of the most formidable of these is the Octopus, which is not uncommon on the southern parts of the British coast. The body of the octopus is about the size of a cocoanut; it is soft and yielding to the touch, and covered by a warty skin, which changes colour with extraordinary quickness, from a livid blue-grey to a speckled brown. Surrounding the mouth, and below the two unwinking eyes, are the eight arms or tentacles: sometimes a couple of feet long, tapering, whiplike, always restlessly curling, and armed all along their inner surfaces with rows of round suckers, closely set, varying from the size of a shilling to that of a threepenny bit. As the animal sits in a corner of a pool, with its arms all coiled under it in spirals, with the suckers outwards, the body throbs with a slow pulsation: when it swells, water is drawn in to wash the gills; a moment later, with a strong contraction, it is forced out again through a small funnel set behind the head, often with force enough to stir the surface of the pool. This is a slow, heavy kind of breathing. There is nothing quite so terrifying as an octopus, not even the lurking spider or the

The Octopus.

Photo: F. W. Bond.

LESSER OCTOPUS (*Moschites cirrhosa*) RESTING.

Photo: F. W. Bond.

LESSER OCTOPUS, SHOWING THE SUCKERS ON THE EIGHT ARMS.

It is difficult, as Homer knew, to pull an octopus out of its hole among the rocks, for its muscular suckers take a very firm grip. They are equally effective in crawling about and in catching crabs. A very interesting feature is the frequent change of colour, partly as the expression of the animal's moods, and partly in response to the colour of the surroundings.

Photos: F. Martin Duncan, F.R.M.S., F.Z.S.

1. MASKED CRAB BREAKING COVER. 2. MASKED CRAB EMERGING FROM SAND. 3. FEMALE MASKED CRAB, FOOTPRINTS AND BURROW.

The masked crab (*Corystes cassivelaunus*) is well-known on British shores, where it burrows in the sand, and sucks in water for breathing purposes through a tube formed by an interlocking of the bristles of the antennæ. The tips of these antennæ project on the surface. On the dorsal surface of the shell there is a marking like a mask, hence the crab's name.

venomous snake: and stories of giant "devil-fish" furnish material for the most breathless of nightmares.

And now if some hapless crab chance to tumble into the pool within reach, one of the long arms is deliberately yet swiftly unwound and falls across the crab's smooth back, where the suckers take instant hold. No time for burrowing, nor for striking attitudes of defiance! Only too lucky if it can wrench itself away, the crab hurries as fast as it can, tumbling off stones, blundering against others, heedless of anything but escape. Slowly at first, and very smoothly, the octopus sets off in pursuit, crawling along on its eight arms. If this is not fast enough, the octopus may start swimming—quite a different movement, for it swims backwards, with the arms trailing behind. It swims as it breathes, by forcing out a jet of water, and each stroke drives it six feet or more. As it touches bottom again, the eight arms are smoothly and simultaneously coiled up as if into a pattern. In another moment, the octopus will unfold upon the unhappy crab (which never appears to offer the slightest resistance), catching it with several arms at once, and with the largest suckers, which are at the base of the arms. Once truly caught, the crab has no chance of escape; though the octopus may, if it chooses, hold it a long time in its arms without beginning to eat it.

Other Molluscs.

The common sea-shells, such as the limpet, the cowrie, and the clam are more nearly related to the octopus than one might at first suppose. In comparison, their lives seem to be uneventful and their movements sluggish; and there are some, like the oyster and the mussel, which never move from the place where they first settle down. Many others only creep about like snails, but there are a few which are more vigorous: the razor-shell can burrow in the sand very quickly indeed, and can also swim a little in the same way as the octopus, by squirting out a jet of water; the cockle and some others can take small jumps; while others swim in quite a different way. The scallop, for instance, a big two-valved shell, not unlike the oyster, lies on the surface of the sand or gravel, with the two valves slightly apart, and when disturbed it usually replies by shutting the valves firmly together. But this is no protection against its arch-enemy, the starfish, from which the scallop always seeks safety in flight. When it feels the starfish's arm pass over it, it swims away, opening and shutting the two valves with quick flapping movements, and in this way steering an erratic course through the water.

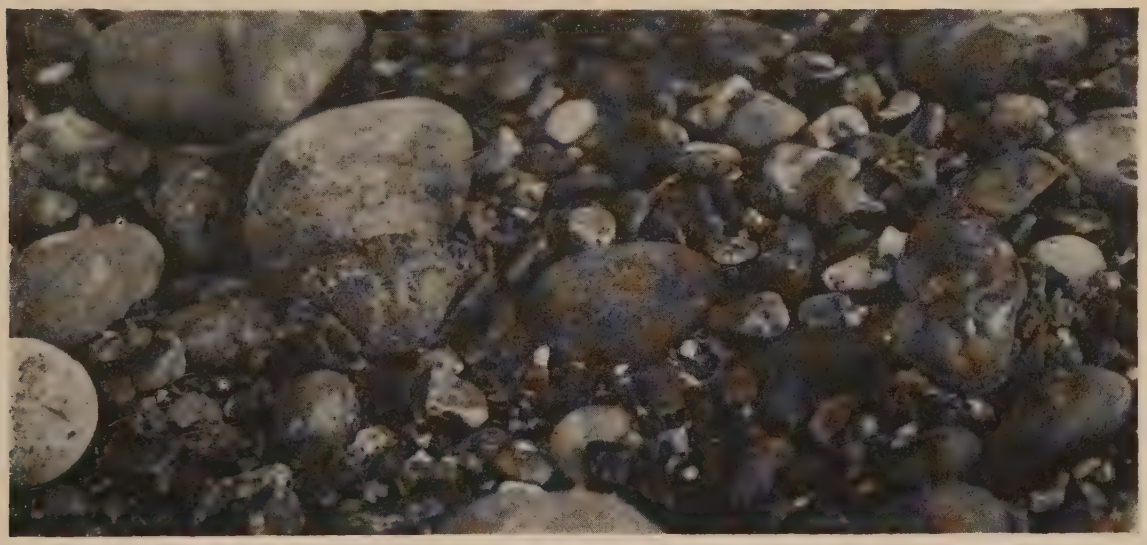


Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

COMMON SHORE-CRAB (*Carcinus mænas*) AMONG THE STONES.

The common shore-crab shows a great variety of colouration, such as greenish, greyish, and reddish, and it is sometimes very like the stones or rocks among which it lurks. The young forms seem to take on something of the colour of their surroundings during the time that their shell is hardening after a moult; and the variety of colour decreases with age.

Photo: Edward Step, F.L.S.

LONG-LEGGED SPIDER-CRAB (*Macropodia rostratus*).

Many kinds of spider-crab are common in shallow inshore waters on Atlantic and Mediterranean coasts. They form the family Maiidæ, and are marked by the much elongated walking-legs and great claws, and also by the triangular carapace. They do not burrow, but often show a protective resemblance to their surroundings. Common on British shores are representatives of Hyas, Inachus, and Stenorhynchus.

But it travels quite blindly, and often in a circle, so that it may come back to the very spot from which it started. If it finds the starfish still there, or if it lands on another one, it may start out again, but much less strongly; and a third swim will exhaust it completely. Thereafter it has recourse to merely passive resistance; it shuts the valves very tightly and holds on with all its strength.

The Starfish opens a Mussel.

But it seems strange that a starfish should be able to open a scallop, or an oyster, or a mussel. The octopus cannot do it, and yet it is far more muscular than the starfish; and everyone knows that an oyster is very difficult to open. How does the starfish manage? The under surface of each of the starfish's arms is divided by a deep groove, running the whole length, from which are protruded the "tube-feet": thin, flexible tubes, which can take hold of objects by suction, for example when the starfish climbs over rocks. They are not powerful sucking discs, like those of the octopus, but they are very numerous. With these the starfish grasps the valves of the shell. It raises its body into a hump, and stands on the tips of its five arms, so that it is able to grip the shell with all five at once, and to pull from both sides simultaneously. Now, although a mussel or an oyster or a scallop can resist a very strong pull, for a short time, it cannot long resist a steady, continuous strain; so that in the long run the starfish manages to pull the valves apart, thus exposing the soft-bodied animal inside. The starfish has a very elastic stomach, which it can squeeze out through its mouth so as to envelop its prey; and in this way the soft flesh of the victim is completely digested.

Sea-anemones.

Very common on all rocky shores are the Sea-anemones. When the tide is out they close up, and appear to be merely rounded blobs of glistening, pulpy flesh, a little like small, soft figs; the commonest are dark brown and deep red. But when

the tide comes in, they open out, as we may sometimes see in a rock-pool. They unfold themselves, as a flower is unfolded when the bud opens; but instead of having petals, they are fringed with a circle of short, thin-walled tentacles, which surround the mouth. They are able to move about by creeping on the rock to which they cling, but instead of hunting as the crab and the octopus and the starfish do, they prefer to remain still and wait for some victim to come their way. Their tentacles are armed with stinging cells, not strong enough to hurt our hands, but able to catch and paralyse any small animal. Little crabs and shrimps, little fishes, or any scraps of flesh in the water, which chance to brush against the tentacles, are caught and pushed inwards to the mouth, and swallowed. In doing this the tentacles act automatically, like a dog that scratches itself in its sleep; and, therefore, it is quite easy to cheat them, with a little stone or bit of paper, which they will grasp just as eagerly as though it was good to eat. But it is very interesting to find that we cannot go on cheating one anemone for long; after a little, it will refuse to take any notice of our deceptive baits; we have tried to take it in once too often. Now the anemone is an exceedingly simple animal, much simpler even than the starfish: it is circular, it has no front or back, nor right and left: it cannot be divided into body and head: it has nothing at all that can be called a brain. Yet, as we have seen, it can do things that are not merely automatic: it can learn a lesson, and remember it for some time.

When the tide goes out, or when it is disturbed or interfered with, the common red anemone shuts itself up; it contracts into a shapeless blob of jelly-like flesh; and so do many of its relatives. But there is one, quite common on the southern and western coasts of England, which does not do this. Its body is dull brown, and its tentacles are long, slender, and very numerous; they may be brown, or buff, or ashy grey, or green with reddish tips; and they are not tucked out of sight when the creature is disturbed. In some places at least, this anemone has entered into a strange sort of alliance or partnership with a peculiar crab. This, the Long-legged Spider-crab, as it is called, is very unlike the common Shore crab in its ways. It has a small triangular body the size of a half-penny, its claws are not very strong, but its legs are exceedingly long and slender, so that the full reach from tip to tip is from four to six inches. One might imagine that an animal with such long legs was built for speed, but as a matter of fact the Spider-crab is excessively leisurely in all his movements. Each step forward seems to require a slow hoist upwards, a sort of lurch forwards, and a gentle settling-down, followed by a pause for reflection before the next stride.

Study of Spider-crab and Sea-anemone.

This Spider-crab, like some of its relatives, has a way of decorating itself with bits of seaweed and so forth, so that it becomes difficult to detect; but besides this, it at times takes shelter in the shadow of the long, snake-like tentacles of the anemone of which we have spoken. Here, of course, it is not merely hidden but defended by the anemone, which in turn appears to make no effort to capture and eat the unbidden guest.

Sometimes a scrap of flesh chances to fall on the floor of the rock-pool, just beyond the reach of the anemone's tentacles. Then the crab, like the giant in the story, becomes aware that there is something to eat not far off; and it sets off on a voyage of discovery, which eventually ends in its finding the prize—the stray crumb from the table of some untidy feeder—fish, crab, or lobster. Now the first thing the spider-crab does is, not to eat up its booty, but to drag it back to the protecting shelter of the anemone, for greater safety. But in a moment one of the tentacles of the anemone brushes against the crab's prize, and at once it is captured and pulled from the crab's uncertain grasp, and swallowed; leaving the crab, with every appearance of bewilderment, to resume in vain its anxious searchings of the neighbourhood. But the crab gets its turn at last, many hours later, when the anemone has quite done with the scrap of flesh; almost the whole has been digested, leaving only a thin white film, which the anemone forces out of its mouth. Once again the crab starts to search, with as much appearance of energy as it ever displays; and in the end it will find, and eagerly devour, the white film that the anemone has found no use for.

There are other animals, even simpler than the anemones; and the simplest of these are microscopic single cells. They are units of living

matter without a true body. Some of them, related to the chalk-forming Foraminifera, creep about on the seaweeds in shallow water, and have very beautiful shells of lime. Others, known as Infusorians, move swiftly about in the water propelled by living lashes (cilia and flagella). One of these Infusorians, called the Night Light or Noctiluca, is about the size of a pin's head. It is brilliantly phosphorescent and makes the oars drip sparks on the late summer evening. Some will entangle on your fingers if you let your hand trail in the water when the boat is moving slowly. Many Infusorians frequent the shore-pools and others live in countless myriads in the open water, where they feed the small crustaceans which feed the herring and the mackerel.

The Simplest Animals.

In freshwater pools there are common animals called Amœbæ, often about a hundredth of an inch in diameter, and illustrating how comparatively simple a living creature may be while still possessing all the ordinary activities of moving, feeling, feeding, growing, multiplying, and so on. An Amœba has no fixed shape, but continually changes as it glides along. When it swallows anything it simply wraps itself round the particle of food, so that this passes into the interior.

An American professor once watched a large amœba swallow a small one in this way, by simply engulfing it. But a little later, the small amœba was able to escape from the larger one, which then changed the direction in which it was moving, so that it caught up with and recaptured its prey, and again swallowed it. Once again, however, the smaller amœba managed to make its way out of the larger one, and this time it made good its escape. Even this, then, one of the simplest of living creatures, possesses something that we must call a mind.

XXXVIII
HOW BRITISH MAMMALS HOLD THEIR OWN

IT takes a long time to become at all familiar with our common Birds or Insects—one must begin early; but anyone can soon get to know the British Mammals, up to a certain point at least. For the list is so sadly short.

§ 1

Why has Britain far fewer different kinds of mammals than Russia, or North America? The answer is interesting. Long ago (in the Pliocene) Britain was simply part of an outlying corner of the great Europe-and-Asia Continent, and it had its full share of the North European mammals, including big creatures like the Mammoth, the Woolly Rhinoceros, the Cave Lion, and the Cave Bear, all of which are long since extinct. Their bones remain here and there to tell the tale.

The Present-day British Mammals.

But the climate became much colder in the north and the Ice Ages set in, covering the country with snow-fields and great glaciers. Nowadays we can see the results of the work of these glaciers in the moulding of our hills and valleys, in the long parallel scratches (or striæ) on the hard rocks, and in the deposits of boulder-clay due to the fine mud carried by the ancient glacier-rivers. During these very severe times most of the British animals were killed off, except those that could migrate, like the birds, and those that were wise enough to trek for the south. There seems to have been a clear tract along what is now the South Coast of England, and as there was no English Channel in those days it would be open to animals to retreat towards the Mediterranean sunny lands. There were four Ice Ages, with three milder (Interglacial) periods between, and the result was practically a wiping-out of the British Fauna. During each of the milder interruptions there would be a return of sanguine animals, to the low grounds at least; but with the return of severe cold they would have to retreat again or perish. In the later Ice Ages there were *men*

Specially drawn for the work by Richard Ockle

HIGHLAND RED DEER (*Cervus elaphus*).

This noble animal used to be widespread throughout Britain in the days when the forests were extensive. It survives in a wild state in the Scottish Highlands, the Island of Mull, the Hebrides, Devonshire, and Somersetshire; but it is also kept in many parks.

Photo: F. W. Bond.

THE PINE MARTEN (*Martes martes* or *Mustela martes*).

This is the largest of the weasel tribe, but is now very rare in Britain. It is by nature a creature of the woods, usually breeding in trees, but it may also find shelter in rocky country. It feeds chiefly on birds and small mammals.

in North Europe, but the oldest known remains of the "modern man type" (*Homo sapiens*) date from after the Ice (Post-glacial).

Milder climate eventually set in and the ice sheets shrank and disappeared, leaving Britain woefully poor in living creatures. But re-peopling from the Continent soon began, and a fine fauna was re-established in Britain, including such mammals as reindeer and the gigantic "Irish Elk," wild cattle and wild boars, beavers and lemmings, wolves and bears. These must have been stirring times—*the times of recolonisation*. But where are these interesting animals now? The answer is that after the recolonisation had gone so far, changes of level occurred in that part of the earth's crust, and Great Britain became an island. The same happened to Ireland, and the insulation occurred before some of the mammals that Great Britain had re-acquired had been able to reach the sister isle. Thus there is no evidence that Ireland ever had the mole or the common hare. When there was no longer any great land-bridge by which animals could enter Britain from the Continent, any further additions would be confined to flying creatures—bats, birds, and insects; and swimming animals, such as seals, porpoises, and fishes. Left without any more recruits from outside, the British mammals soon began to dwindle in number of kinds. There was competition, no doubt, among themselves; thus the wolves thinned the ranks of the reindeer, just as in the north of Canada to-day. The improvement of the climate probably went too far for the welfare of others: thus the Mountain Hare, like the Ptarmigan among birds,

Photo: Frances Pitt.

HEDGEHOG DRINKING.

The hedgehog seems to become uncomfortable during prolonged drought and keeps itself more than usually well hidden. It enjoys its drink of water and can swim quite well with its back projecting above the surface.

could only survive by keeping to considerable heights. Again, it is possible that some of the animals brought about their own destruction by going too far in some particular direction, by becoming "extremists." Thus the Giant Deer (badly called Irish Elk), whose remains are found in peat-bogs in Ireland, seems to have gone too far in its enormous growth of antlers, which must have become a burden too grievous to be borne. They sometimes had a spread of ten feet; they sometimes weighed as much as 80 lbs.; and they had to be grown afresh every year by the stags.

But the chief reason for the dwindling of British mammals was Man. He hunted to procure food and clothing; and the ranks of the reindeer and the wild cattle were thinned. He hunted to secure his own safety and that of the flocks of sheep and herds of cattle he was beginning to establish, and the wolves and bears became fewer. Afterwards he hunted for "sport," but that did not do so much harm. Much more serious was the cutting down of forests in which Red Deer, Beaver, Pine Marten, and many more had found shelter. He began to cultivate, joining field to field; and that was very much against creatures that like wild and sheltered places. In scores of ways Man has been responsible for making the list of British mammals as short as it is.

Reindeer and wolves lingered in Britain till historic times, but they have long since gone; and so it is with some other fine mammals. Wild cat and pine marten were common two centuries ago, but they are now very rare; and so is it with some others. The quaint badger was once widespread, as is proved by the many place-names beginning with "Brock," which is one of the creature's aliases; but it is now confined to a few districts. The same is true of the polecat, which is either the ancestor or the first cousin of the domesticated ferret, much used in rabbiting. What we wish to do is to select *some common or fairly common* British mammals, and ask how it is that they remain when others equally well equipped have disappeared or become very rare.

§ 2

Take the mole to begin with: How does it hold its own so well? The answer must be that it has discovered the under-world and become

Photo: Frances Pitt.

A MOTHER HEDGEHOG, WITH ITS YOUNG.

Early in summer the hedgehog gives birth to four to six quaint young ones, cradled in a nest of dried leaves and grass. The spines are soft and pale at first, and take about three weeks to harden and brown. The eyelids are sealed for about a week. A mother hedgehog has six pairs of teats. New-born hedgehogs, deserted by the frightened mother, have been successfully reared on milk and dainty food—a noteworthy achievement in artificial nurture.

Photo: Frances Pitt.

THE COMMON MOLE (*Talpa europæa*).

The photograph brings out some of the characteristic features —the barrel-like body, the pointed snout, the absence of projective ear-trumpets, the strong hand, the weaker foot, the short tail, the velvety fur without "set." Moles forage above ground at night, and they pair above ground. Much of the day is spent in exploring for food just below the surface. They are very restless creatures, of almost furious energy.

a burrower. It comes to the surface to find its mate or sometimes to get water to drink, but in the main it is a dweller in darkness, feeding on grubs and earthworms, and suited from snout to tail for subterranean life.

The Insectivores.

The Common Shrew and the Pigmy Shrew, how do they hold their own? The answer must be that they are very small, very alert, very quiet, very inconspicuous "little people." They are shallow burrowers, feeding on insects and many other kinds of small fry, much given to hunting in the twilight or later. Of some service to the Common Shrew is a line of skin-glands on each side of the body, which secrete an unpalatable stuff, with a repellent smell. This is almost better than armour against certain enemies. But it does not always work, for owls are not repelled, and although cats never eat shrews, they kill them.

On a slow-flowing part of a stream we sometimes see a little creature swimming across just below the surface of the water and keeping its body very flat. It moves quickly enough, rowing with its tiny hands and feet, but so gently that there is scarcely a ripple. This is the Water Shrew (*Crossopus fodiens*), a relation of the Common Shrew. There are plenty of them in many parts of Britain, but few people notice them. The Water Shrew is brownish-black above, greyish-white below, with the long, pointed snout characteristic of shrews in general, and with a fringe of hairs on each side of its long tail, which serves as a rudder. It burrows in the banks of the stream and is an engaging animal. Its young ones are said to be delightfully playful, and they would reward further study. How does the Water Shrew

Photo: Frances Pitt.

THE SO-CALLED "FORTRESS" OF THE MOLE (*Talpa europæa*).

A "fortress" is a large mound of earth, often about the base of a tree, and it represents the mole's winter quarters. It is surrounded by irregular, but connected, tunnels. It is to be distinguished from a mole-hill which consists merely of the earth thrown up at intervals in the everyday burrowing. The female's "fortress," made for breeding purposes, is larger and simpler.

succeed in the battle of life? The answer must be that it keeps *very* quiet; that it is very inconspicuous and elusive; that it can feed on a great variety of small animals, such as insect larvæ; and, most of all, that it has taken to the water. Another point, which applies to all the shrews, is that Man does not interfere with them if he thinks of what he is doing, for they check the spread of insects.

The mole and the shrews belong to the order of Insect-eaters (or Insectivores), and another member of this order is the hedgehog (*Erinaceus europæus*), an old-fashioned creature, which is common over the vast area from Great Britain to the Ural Mountains. It is a biggish animal, so it cannot escape as the shrews escape—by being little. It is not a burrower like the mole, so getting underground is not its secret. Though it can swim, it is not fond of the water, so we cannot explain its survival as we explain that of the Water Shrew.

What then is the hedgehog's secret? How does it manage to survive in a country which, as we have seen, is not friendly to mammals? How does it hold its own in a land where the spread of cultivated fields (and golf-courses too) is continually reducing the number of wild places, and where wild creatures have many enemies, especially in Man himself?

Many of the hedgehog's hairs have been turned into sharp spines, which make the animal almost invulnerable. They also break its fall if it should tumble when it is climbing, as it is fond of doing. It can roll itself up into an unopenable ball, which puzzles even the crafty fox. It has a very tough constitution and is not even hurt if it gets a bite from the adder—one of its inveterate enemies. Another useful quality is that it can eat so many different kinds of animals, such as earthworms, slugs, small snails, and beetle-grubs. It does practically no harm, and to kill a hedgehog is the depth of silliness. When the cold weather sets in and animal food is scarce, the hedgehog falls into the strange state called "winter sleep" (or hibernation), "lying low and saying nuffin'," and requiring nothing to eat or drink. That is not all, for the hedgehog has made its foothold more secure by becoming nocturnal. It rests during the day in the recesses of the hedge or in the bole of a hollow tree; it hunts at night, when nobody can see it. When we hear its queer loud voice at night, we feel that the hedgehog knows that it is safe.

§ 3

The Gnawing Mammals or Rodents.

When we turn from the Insect-eaters to the Gnawing Mammals (or Rodents), we find a different state of affairs—for many of them are not only common, but far too common. Rats and mice and voles are so common that people give them the ugly name of "vermin." They do a great deal of harm to all sorts of crops and stores. There were no rats in Britain before the Norman Conquest, but we may include them with the Field Vole, the Bank Vole, the House Mouse, and the Wood Mouse in our question: Why do so many gnawers become such a pest? The answer is threefold. They succeed because they multiply so quickly. They are not very strong; they are not very clever; but they are many. Secondly, they succeed because they find in fields, in stores, and in Man's careless accumulations of "crumbs" of all sorts, an unnatural abundance of food. Thirdly, they succeed beyond measure because Man has greatly reduced the number of their natural enemies, such as hawks and stoats, owls and weasels.

The Water Vole (*Arvicola amphibius*), which cannot get rid of its "bad name" of "Water Rat," occupies a place by itself. It does not multiply quickly, compared with the Field Vole, and yet it holds its own. Its particular secret lies in having become in the main a water-animal. This greatly reduces the number of its enemies; it has found a corner of its own. When it makes excursions on land to potato-pits and the like, it is usually at dead of night. For the sake of clearness, let us state why in strict speech we should not call the Water Vole a "water rat." It is on a different line altogether. Its snout is blunt, its head is broad, its ear-trumpets are much reduced, its tail is hairy, its back teeth have a different pattern. Call a spade a spade, if you like, but do not call a water vole a water rat, nor a field vole a field mouse. On the other hand, a universally used name has rights of its own, and, personally, we see no reason why the water vole should not be called the "water rat," so long as we are clear that the name is zoologically wrong.

Photo: John J. Ward, F.E.S.

LARGE BROWN RAT ON PROWL IN MID-WINTER, SHOWING THICK, SHAGGY COAT.

One of the difficulties in dealing with the brown rat (*Mus norvegicus* or *decumanus*) is its readiness to shift from place to place. When food becomes scarce or when stern measures are taken against its increase, the rat treks elsewhere.

Photo: John J. Ward, F.E.S.

MUZZLE OF LARGE BROWN RAT, SHOWING PROMINENT TEETH.

In all rodents or gnawing mammals, with the exception of the hares and rabbits, there are just two incisor teeth above and below, the exceptions mentioned having two pairs above and one pair below. These teeth are chisel-edged, for as the enamel is confined or almost confined to the front, there is a quicker wearing away of the posterior surface, and this produces and retains a sharp cutting edge.

We need not say much about the rabbit, for the secret of its success is largely to be found, like that of the Field Voles, in the large families and in the ease with which grassy food can be procured. In spite of foxes and birds of prey, and all man's shooting and trapping, they hold their own with ease. We must add, however, that their foothold is also ensured by their burrowing habits and by their preference for feeding and playing at dusk. There is safety also in their danger-signal, made by thumping hard on the ground with the hind-feet. Even such a little detail as the bright white colour of the underside of the tail may have its value, for it serves in the twilight as a guide to the inexperienced youngsters, when the quickness of a bolt for the burrow is a matter of life and death.

How do the hares succeed? The Common Hare (*Lepus europæus*) is persecuted by the fox, and the young ones or leverets are eagerly sought for by the stoat, yet the attractive creature keeps its foothold. What are its secrets? It has very keen senses of sight, hearing, and smell; it is always on the alert. It takes a great leap out of its resting place when it leaves, and a great leap into it again when it returns—a simple device that breaks the scent. Not only is the hare extraordinarily swift, but its heart is so adjusted that it can put on full speed in a moment. Then it criss-crosses its tracks, so that the fox is puzzled. On the ploughed field and among the withered herbage the animal is very inconspicuous; its fur is a garment of invisibility. The mother is very careful of the young ones, and this makes for success. When they are very young she will shift them at night to another cradle, if the fox seems to be getting "hot" in his persistent searching. When they are able to run about, she teaches them for a while.

Compared with the Common Hare, the Mountain Hare or Variable Hare (*Lepus montanus*) has a stronger constitution, suited to life at high altitudes, and it is able to thrive on rougher food. When winter approaches, the Variable Hare puts on a white suit, all but the black tips of the ears. Against the background

Photo: Frances Pitt.

KITTEN OF WILD CAT, EXPRESSING ANNOYANCE.

Wild cats make their lairs in remote places, inside a decaying tree or in holes among the rocks. Five or six kittens are born early in summer, and are carefully looked after and instructed by the parents. The relation of the wild cat to the domesticated cat remains uncertain.

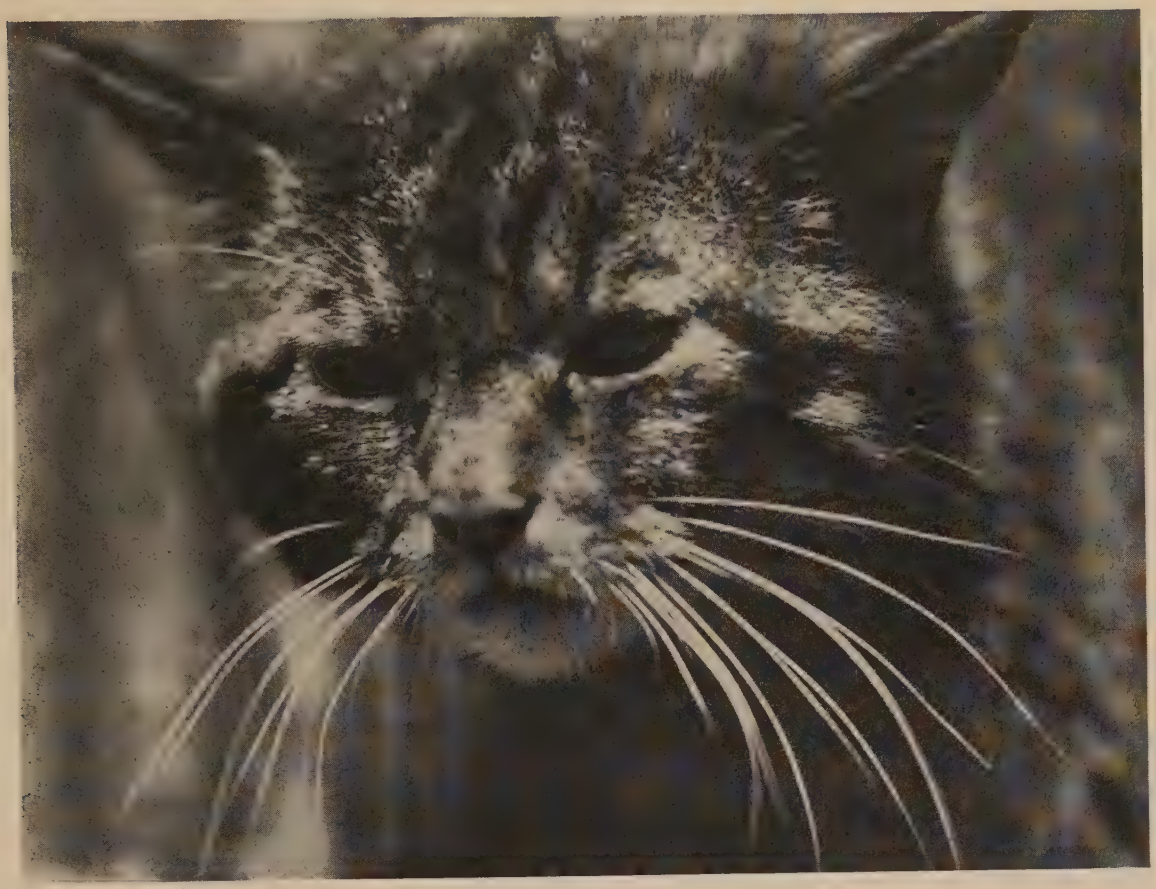


Photo: F. W. Bond.

THE WILD CAT (*Felis sylvestris*).

This handsome representative of the cat tribe used to be common throughout Great Britain and Ireland; it is now restricted to the more secluded parts of the Scottish Highlands, and is very rare. The species must of course be distinguished from domesticated cats which have become wild or feral.

of snow it is very inconspicuous, and this may save it from the eagle's hungry eyes. But the deeper meaning of the white fur is that it keeps the hare warmer; it loses less of the precious animal heat of the body than brown fur would.

As for the joyous squirrel, which is also a Rodent, its success depends on its having got off the ground. It has found a new world among the branches, and we might argue from its cheerfulness and playfulness that it is not much troubled about safety or bread-and-butter. In a forest it is almost like a bird in its freedom of movement from tree to tree, and it is like a bird also in making a lofty nest in which the family can be reared in safety. Even when the squirrel comes to earth to eat a palatable toadstool or bury a nut, it is still very safe, for there is always a tree-stem within jumping distance. The importance of the storing habit has perhaps been exaggerated, but there can be no doubt that the caches of acorns and beech-nuts are sometimes of use in very hard times. Even at Christmas time one may see the squirrel jumping from one snow-laden branch to another, so it is not a winter-sleeper. Safe as the squirrel is, it was exterminated in Scotland by the end of the eighteenth century, as the forests dwindled. The large numbers that we see now are the results of subsequent re-introduction.

§ 4

The Carnivores.

The Carnivores or flesh-eating mammals now found wild in Britain belong to four tribes. Highest is the Cat tribe, represented only by the very rare Wild Cat, a powerful carnivore of the woods, not nearly related to the imported domestic cat. Then there is the Dog tribe, also with only one wild representative, namely the fox. Thirdly, there are various seals, which have taken to the

Photo : Ellison Hawks.

THE STOAT OR ERMINE (*Mustela erminea* or *Putorius ermineus*).

The photograph shows the stoat in its chestnut-brown summer dress ; in winter it becomes the ermine, all white save the tip of its tail. In the main the change is due to the replacement of the brown hairs by a fresh growth without pigment.

sea—splendid swimmers, but unable any longer to stand on their hind-legs. Lastly there is an interesting set of carnivores that represent the Bear tribe, not so high up in the scale as Cats and Dogs, and not so peculiar as the Seals. The Bear tribe includes badger, otter, polecat, weasel and stoat. The example we select is the chestnut-brown stoat—a creature much persecuted by the gamekeeper, but still holding its own in spite of heavy odds. In winter it puts on white fur, all but the black tip of the tail, and in this garb it is known as the ermine. What are the secrets of the stoat ?

The stoat is one of the lithest of mammals, without an ounce of spare flesh, as supple as a snake. It can disappear through what seem impossibly narrow passages. It is always in good form, quick of sight and hearing, with a keen sense of smell, always on the alert. One cannot take a stoat by surprise, unless it is very deeply interested in its "kill." The mother takes great care of her half-dozen young ones, and she trains them well in the ways of the woods.

But the stoat's chief secret is its resourcefulness and its doggedness. One has been known to swarm up a zinc ventilating pipe that led through the roof of a greenhouse, wrench off the wire-netting at the top, slide down the pipe, kill two squirrels in a cage, suck their blood, and then climb up the pipe again—a very remarkable feat—and so off. We are almost sorry to read that when the stoat returned next day for the other squirrels it was killed by their owner who was naturally anything but pleased at the previous day's escapade. For a short distance a rabbit can outrun a stoat, but the stoat has better wind and more endurance, and wins on a long race. The rabbit gets flurried ; it is seized with a strange fear-paralysis ; and the stoat is at its throat, biting the great vein in the neck.

You may stand in the way of a stoat that is landing from a swim across a river, but you will not turn it aside. If you are foolish you may perhaps brain it with a stone, but you will not baulk it. For it has not a trace of fear in its composition. A mother stoat, leading her family, will stand up to a gamekeeper and his dog. Perhaps we may say, then, that a stoat holds its own by alertness and force of character.

As we have mentioned, the chestnut-brown summer stoat becomes the snow-white winter ermine. It gets a new suit of fur ; but some individual hairs may also whiten. The winter whiteness makes the ermine inconspicuous against the snow, and may help it to steal upon the grouse or escape the eagle's detection. But we believe that its chief use, as in the case of the Mountain Hare, is that it loses less of the precious internal heat of the body than would be lost if the fur were brown or any other colour. It is interesting to notice that in some places where the winters are comparatively mild, the stoat has a brown winter coat, while the stoat

of the Scottish Highlands always becomes an ermine when the cold weather sets in.

From the success of the stoat it is easy to understand the success of its small short-tailed cousin, the weasel. But it does not change to white in winter. As to the badger and the otter, they cannot be called common except in a few parts of Britain, and we shall refer to them in another connection. Coming to Reynard the Fox, he would probably have disappeared long ago from a country so artificial as Britain had it not been for fox-hunting. This seems a strange thing to say, but the sport has such a hold on the English people that killing a fox, except in the chase, is regarded almost as a crime! So foxes tend to increase just because so many people wish fox-hunting to continue.

As to seals, which are sometimes to be seen in scores on the West Coast of Scotland, the main secret of their survival is that they have become so thoroughly aquatic. Their ancestors left the crowded land and took to the friendlier sea, where seals are now at home. The dangerous time in the seal's life is when the mothers have to come on to the shore rocks to give birth to the young ones, and when these young ones are lying helpless, unable even to swim if they tumble into the water. Many animals that have changed their habitat go back to the old home to start another generation.

§ 5

Cetaceans.

Belonging to a very different order from the seals are the porpoises and dolphins, which are often to be seen playing in the sea off British coasts. They belong to the order of whales or Cetaceans, and they show in various ways that they have been aquatic for a much longer time than the seals. Thus there is no external trace of the hind limbs, and there is no hair on the body. Porpoises and other Cetaceans have this great advantage over seals, that the mother can bring forth her young one in the water and suckle it there. This means that the ancestors of porpoises must have left the dry land long before the ancestors of seals got that idea into their heads, and so porpoises and their relatives greatly excel seals in their fitness for aquatic life.

§ 6

Bats.

There are certain familiar and very common British mammals that we have not mentioned yet—namely the Bats. They have four chief secrets. First of all they can fly. They have found a new kingdom into which no other mammals can intrude; and they are almost as well suited for aerial life as birds. Secondly, they are nocturnal, hiding during the day and coming out at dusk

Photo: Frances Pitt.

YOUNG GREY SEAL (*Halichœrus gryphus*).

This fine seal, which may attain a length of eight feet, is not uncommon on the shores of the Hebrides and the Shetlands, and of the West and South of Ireland. Its colour is yellowish-grey with darker grey spots and blotches.

to hawk insects, sometimes high in the air, sometimes so near the ground that they almost brush our face. But they have a marvellous sensitiveness that keeps them from knocking against anything. Thirdly, bats fall into a "winter-sleep" when the cold weather comes. It is a true hibernation, but it is not so deep as the hedgehog's, for bats awaken if there is a spell of mild weather—even at Christmas time. In cold places the bats remain "asleep" all through the winter, clustering together on the rafters of a barn, or in the sheltered nooks of an old tower, or inside the hollow trunk of a decaying tree. Strange creatures that hang themselves up by their toes, and wrap themselves up in their arms! Fourthly, the mother-bat takes great care of her baby—and that always makes for success.

XXXIX

HOW AMERICAN MAMMALS HOLD THEIR OWN

THE mammals of North America (Nearctic) have a general resemblance to those of the north of Europe and Asia (Palæarctic), and the two great regions, considered from the point of view of geographical distribution, are often united under the title Holarctic. In the northern parts of both the Old World and the New, we find such types as tailless hare, marmot, pouched-marmot, beaver, lemming, field-mouse (but no Mus in America), sheep, bison, reindeer, elk, polar bear, glutton, and lynx. But mole, water-mole, badger, camel, yak, chamois, and dormouse may be mentioned as characteristic of the Old World, just as pouched rat, musk ox, prong-horn, Rocky Mountain goat, prairie-dog, musk-rat, skunk, and racoon are characteristic of the New. It may be interesting, therefore, to pick out a few North American mammals and ask how they manage to hold their own. Unfortunately, just as in Britain, it has to be admitted at once that many of them are *not* succeeding. In spite of vigorous protective measures and the wise enthusiasm of men like Dr. W. T. Hornaday, of the New York Zoological Park, there is a sad diminution of such interesting mammals as the unique Prong-Horn Antelope, the Big-Horn Sheep of the Rockies, the Mountain Goat, the Wapiti, the Caribou, the Moose, the Musk-Ox, and even the Grizzly Bear. (See Hornaday's "Our Vanishing Wild Life"). It is to be hoped that greater appreciation of these irreplaceable treasures will save them from extermination.

The Prairie-Dog.

In the interior of North America on the great treeless plains, one of the most characteristic sights is a "town" of prairie-dogs. As the train rushes through on a transcontinental railroad, the traveller may see in suitable places hundreds of plump, somewhat squirrel-like rodents (Cynomys), considerably over a foot in length, sitting bolt upright by the mounds which mark the mouths of their burrows. We read that "in the entire state of Texas 90,000 square miles are occupied by prairie-dogs, and the number of these animals within this area runs to hundreds of millions." They are legion; how do they get on so well?

The first part of the answer is that these gnawing mammals find an abundant food-supply in the stems and roots of prairie-grasses and other plants that flourish in these vast expanses. For relish they will eat grasshoppers and the fruits of the pear-leaved cactus, but in the main they are voracious vegetarians, levying heavy toll on the crops that encroach on their wildernesses. No doubt as agriculture advances, the prairie-dogs must yield; but while they may disappear locally, they are, as a species, safe for centuries. This is the more certain since, like most other rodents, they are very prolific, working with a big margin.

But what is there besides the abundant food-supplies and the prolific reproduction? Being numerous and palatable they are obviously of value to coyotes and foxes, eagles and owls, yet this is in some measure met and baulked by a

high development of social vigilance. When an intruder is detected, a prairie-dog makes for the nearest mound and sitting bolt upright "barks" for all he is worth. Hence, we suppose, the name of " dog," but he also wags his tail. In a very short time, as Mr. Nelson says, "the 'town' is alive with scurrying figures of the inhabitants rushing panic-stricken for their homes, and the air is filled with a chorus of their little barking cries. When all have been frightened to cover, barking continues in the burrows, but an hour or more may pass before a ' dog ' will re-appear." (See "Wild Animals of North America," National Geographic Society, Washington, 1918.) The mothers are said to teach their offspring to obey the danger signal with promptness, and there is great native alertness to start with. Prairie-dogs are very much on the spot, and, as we have said, they will hold their own—even in spite of their dangerous quality of being edible. They have two other advantages, that they can thrive without water, except what they extract from their food ; and that they can hibernate for months in severe weather or in exposed haunts. There is no warrant, of course, for the picture of their " happy family " along with owls and rattlesnakes. " The truth is that the owls live and breed in deserted dog holes, while the rattlesnakes visit the occupied holes to feed on the unfortunate occupants." The prairie-dogs are interesting enough without this brightly coloured legend. As Topsell said in his Apologia (1607) :. " Truth on every part is so deare unto me, that I will not lie to bring any man in love and admiration with God and his works, for God needeth not the lies of men."

Balancing the Ground Porcupines of the Old World are the Tree Porcupines of the New. They are very markedly contrasted with the prairie-dogs, but they belong to the same order of

Photo : F. W. Bond.

NORTH AMERICAN RACOON (*Procyon lotor*).

The racoon, a heavily built nocturnal carnivore, ranges over the wooded tracts of North America from Canada to Panama. Omnivorous in diet, it feeds on fish, flesh or fowl, and on fruit and green corn besides ; but it shows some fastidiousness, for, when it can, it washes its food in water before commencing to eat. It makes its home in hollow trees and rears from four to six young yearly. Characteristic are the alternate black and grey rings round the tail.

Photo : F. W. Bond.

CANADIAN TREE PORCUPINE (*Erethizon dorsatus*).

The young of this Canadian porcupine are very well equipped, for when newly born their eyes are open and they have small quills covering their body and tail. These quills lie flat beneath the coarse black and grey outer coat, bristling in time of danger, and when full-grown are from half an inch to three inches in length. The Canadian porcupine is arboreal, and feeds mainly on bark and leaves.

Rodents or Gnawing Mammals. The name "hedgehog" that they sometimes get is a very bad one, for the hedgehogs belong to the order of Insectivores. Best known, and yet not very well known, among the tree porcupines is the "Canadian" species, *Erethizon dorsatus*, found from Hudson Bay to Ohio,—one of the quaintest of mammals, about twenty times as large as a European hedgehog. It is a black creature, "with a grey-tipped storm-coat"; it is slow-going and slow in the up-take, it has not good sight, and it lives as a solitary. How does it hold its own? Part of the answer is to be found in its use of many kinds of rough vegetable food, such as bark, in its preference for the darkness, and in its arboreal habits. It may stay for weeks on the top of one tree, gnawing at the bark, but it usually has a den on the ground, and it may wander far in search of luxuries like fruit and salt. The young ones are born very large and well-equipped, soon able to fend for themselves, and in this also there must be safety. But when we add up all these qualities, we have not yet explained the tree porcupine's survival, for it has many enemies among predatory birds and beasts with quicker wits. The porcupine is saved by its spines!

The American Porcupines.

These sharp defences are transmogrified white hairs of the under-fur, and are overlaid by the coarse black and grey outer hairs. They lie flat when the creature is quiet; they bristle when it is excited; and they have such a loose attachment to the skin that they break off when the point enters the skin of the assailant. It has a very effective way of swishing its short, club-shaped, spiny tail on the enemy, whose skin is thus pierced by many darts, which may be fatal and are almost certain to be tormenting. But in spite of many asseverations to the contrary the tree porcupine cannot shoot its spines. In this connection we may mention that the same is true of the Old World Porcupine (Hystrix).

It rattles its long spines in raising them; it charges backwards and sideways with them all bristling; and it often loses them, for are they not transformed hairs? But shoot them it cannot. Not even Buffon believed this, for he said on this very subject: "The marvellous is pleasingly believed, and increases in proportion to the number of hands it passes through." The quills of the Old World Porcupine may be over a foot long, those of the Tree Porcupine vary from half an inch to rather over three inches in length. But they are long enough to have "survival value"!

The Mountain Goat.

The Rocky Mountain Goat, *Oreamnos montanus*, is a big-game mammal of North America that holds its own with considerable success. What is its secret? It is a creature of the cliffs, very sure-footed, able to thrive on scanty vegetation, well-protected from the cold of winter by its coat of shaggy white hair. It has a long heavy head bearing small black horns; it is humped at the shoulders like a buffalo; it is enormously strong. It ranges from Alaska easterly and southerly through the mountains to Montana and Washington, and it seems to have few natural enemies. It seems to be a slow-going, not very adventurous creature, believing a good deal in "Safety first." Mr. E. W. Nelson writes of these American wild goats: "They are reputed to show at times a stupid obstinacy when encountered on a narrow ledge, even to the point of disputing the right of way with the hunter." Every game animal is liable to have its range restricted by man's overshooting, but the persistence of the Rocky Mountain Goat is assured by its liking for inaccessible retreats. Dr. Hornaday praises its coolness in finding an unassailable position and waiting there undismayed. "Mentally the Mountain Goat has the steadiest nerves, the most indomitable courage and the greatest coolness in the face of danger that I am aware of in any hoofed and horned mammal." Fortunately, the flesh is too musky and dry to be palatable; the skin is of no commercial value; and the head is not much of a trophy. So the Mountain Goat will live on for many a day.

The Skunk.

One of the most unpopular of mammals is the Common American Skunk, *Mephitis mephitis*, widely distributed from the Atlantic to the Pacific, from Hudson Bay to Guatemala, common in woodland and thicket, and with a very firm foothold in the struggle for existence. What are the secrets of the skunk? As a member of the Mustelid family, beside the stoat and the weasel, the mink and the marten, it is of course highly endowed as regards muscle, brain, and sense-organs. Like

Photo: F. W. Bond.

THE PRAIRIE-"DOG" OR MARMOT (*Cynomys ludovicianus*).

The prairie-"dog" of North America is fourteen to seventeen inches in length. It is first cousin of the ground-squirrels, and has short ears, limbs and tail. It is a voracious vegetarian, feeding on the stems and roots of prairie-grasses, and is quite independent of water except in so far as it is able to extract it from its food; thus it thrives in the driest places.

Photo: F. W. Bond.

COMMON CANADIAN SKUNK (*Mephitis mephitis*).

This species of skunk is common in the woodlands of the northern United States. Its fur, which is in great demand, is jet-black in colour, with two broad white bands down the back. Although the skunk is an enemy of the poultry-yard, it does great service in destroying injurious insects not to speak of mice, wood-rats and other small rodents.

many of their relatives, skunks have a long bill of fare, from grasshoppers to rats, from wasps to frogs, from fish to ground-nesting birds. While they levy toll on game-birds, they pay man back by checking injurious insects. Another reason for the survival of skunks is to be found in the care that the mother takes of her young ones. There are half a dozen or so in the comfortable nest that is made in the recess of the burrow or den, and the mother gives them not only food but education, just as in the case of the otter. When she is teaching them the ways of the woods, they often follow her in a long Indian file. Here we have undoubtedly a kind of matriarchal family life, and it may be kept up for about a year. Another life-saving quality of skunks is that, on the whole, they prefer night to day. But on none of these qualities does the skunk's safety mainly depend. Everyone knows that they owe most of their safety to the intolerable smell of the secretion that they squirt out from two glands situated near the end of the food-canal. The animals are conspicuous by day in their jet-black fur with two white stripes along the dorsal surface, but they move about with deliberation and confidence. "Long experience has taught them that the right of way is theirs." If other creatures dispute it and will not take a hint, the skunks squirt out the nauseous secretion, and the double jet can carry for two or three feet. It must not be supposed, however, that this defence brings them more than partial safety, for many fall victim to the appetite of predatory birds and beasts, such as coyote and puma, harpy eagle and great horned owl. Moreover, the flesh is palatable and the fur is increasingly in demand. Sometimes, indeed, men start skunk farms, where the animals are bred. In these cases the scent-sacs are removed by a simple surgical operation. It may be noted that skunks are rather gentle creatures, by no means averse to man's company and protection; the young ones are playful and affectionate.

Photo: F. W. Bond.

THE HOG-NOSED SKUNK (*Conepatus mesoleucus*).

The hog-nosed skunk has its headquarters in South America, but ranges northwards through Mexico to Texas. It is distinguished from the common skunk by the powerful digging claws of the front feet, and by the single broad band of white along the back. It is a vigorous burrower, hence the name badger-skunk, and largely insectivorous.

Photo : H. J. Shepstone.

THE ROCKY MOUNTAIN GOAT (*Oreamnos montanus*).

The only American representative of wild goats, this Rocky Mountain animal is enormously strong and sure-footed, with high shoulders, low hind-quarters and short, stocky legs. Its thick-set body is covered with shaggy white hair which serves as a protection against the intense cold of the mountain ranges. The head is heavy and the face long and narrow, and the black horns are short and simple. This goat has few natural enemies.

Besides the Common Skunk there is the Hog-nosed Skunk (Conepatus), with a single white stripe along the back. It has its head-quarters in South America, but overlaps the commoner type in its range. It is more of a burrower, more nocturnal, and more insectivorous.

Another relative is the small North American Spotted Skunk, Spilogale, " distinguished from all other mammals by the curious and pleasing symmetry of the black and white markings." It is very varied in its diet, including even fruits and mushrooms ; and it is very unlike the other two kinds in its agile movements. As usual, the Spotted Skunks squirt out a double spray of nauseous fluid. It was of them that Hernandez wrote in 1628 : " The powerful arm which they use when in peril is the insupportable gas they throw out behind which condenses the surrounding atmosphere so that, as one grave missionary says, it appears as though one could feel it." Many carnivores have these scent-glands with a repulsively malodorous secretion, but we get a glimpse of one of the ways of Organic Evolution when we consider the case of skunks, where this feature has been exaggerated into a life-saving habit.

Flying Squirrels.

Widespread in North America are the exquisite Flying Squirrels (*Glaucomys* or *Sciuropterus volans*), which show a life-saving feature without a parallel in Britain, namely, a parachute. This consists of a delicate extension of the skin between the fore and hind limbs, and it enables the dainty creatures to volplane from tree to tree in the dusk. They can control their movements in the air, and ascend at the end of a descent, but there is no real " flying," such as bats show. In other

words, the sheet of skin does not actively strike the air.

The American Flying Squirrels are engaging little creatures, about five inches long and four more to the tail ; they live in holes in trees, sometimes gregariously. They are nocturnal, as their large eyes suggest, and they are sometimes seen playing joyously at dusk. During the day they lie sleeping, rolled up in a furry ball. They are able to thrive on very diverse food, acorns and birds' eggs, beech-nuts and insects ; buds and corn ; and this of course helps them to hold their own. Another quality that makes for success, as we have already emphasised, is the strong maternal care. Mr. E. W. Nelson tells of a case where the helpless young were removed from a nest in a hollow stub and placed on the ground at its base. " The mother soon returned and not finding her family in the nest, promptly located them on the ground. Quickly descending, she took one in her mouth, carried it to the top of the stub, and, launching into the air, sailed to a tree thirty feet away, up which she carried her baby and placed it safely in a knot-hole. The trip was quickly repeated until the family was re-united in its new location." One feels that the Flying Squirrel has a right to survive !

These instances must serve to illustrate the variety of ways in which American mammals hold their own, but the subject is endless. Everywhere we see creatures utilising some device, some niche of opportunity, some new departure or other in structure or in habit, which strengthens their foothold in the struggle for existence and the endeavour after well-being. The opossum feigns death and is often successful in making its escape ; the gophers or pocket-rats live as miners beneath the ground ; many of the squirrels have found safety in the tree-tops. The minks among carnivores and the musk-rats have taken to the water where they hunt respectively for fish and water-plants. Many American mammals have sought and found safety in darkness ; a few are camouflaged ; others have made a strength out of a weakness by falling into winter-sleep ; a few have proved in their sociality that union is strength. But the problem to which these are answer is always the same. The problem is to keep body and soul together. " Why do the people strive and cry ? " the poet asked, and the answer came : " They will have food and they will have children, and bring these up as well as they can." This is true of " people " ; it is also profoundly true of animals.

Many Inventions.

Photo : W. S. Berridge, F.Z.S.

AMERICAN FLYING SQUIRREL (*Sciuropterus volans*).

These attractive little creatures are widely distributed from Canada to Florida, west to Louisiana, and as far south as California. Nocturnal in their habits, they are rarely caught sight of ; but sometimes at dusk they can be observed gliding by means of their delicate skin parachute from the branches of one tree to those of another, and gambolling in a fascinating manner. They have a length of about five inches to the head and body, and four more to the tail.

THE NEW NATURAL HISTORY

First Volume

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